PROCEEDINGS

OF THE

AMERICAN PHILOSOPHICAL SOCIETY,

HELD AT PHILADELPHIA, FOR PROMOTING USEFUL KNOWLEDGE.

VOL. XIX. JUNE TO DECEMBER, 1881. No. 109.

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called the name of his first born Manasseh; for God hath made me forget all my toil and all my father's house. And the name of the second called he Ephraim: for God hath caused me to be fruitful in the land of my affliction." The Hebrew Scriptures are full of such punning etymologies of later times when true meanings of the old names had been lost, and new meanings had to be invented and corroborated by fictitious anecdotes.*

The fiction is particularly unfortunate in this instance, since the legendary name of Joseph's wife and Manassah's mother is Asenath, AS-NUT "image of the goddess Naut," a perfectly well known Egyptian compound. And the legendary name of her child *Manassa*, "Image of Menes, agrees strictly with her own." One of the elements in the compound being the same in both names; and the demigod first Pharaoh Menes being substituted in the name of the boy, for the divine Neith in the name of the mother.

The name of the founder of Egypt is written MNA, and the etymology claimed for it is got from the verb *man* or *men* in its meaning of *stability*, preserved in the Latin *manere*, to remain. The word AS is used monumentally for *throne* and *statue*, and for *prince*. Both throne and statue represent royalty. *Man-Assa* would then mean "firmly established royal power."

Whether this was really the sense ascribed to the name, or whether it was understood in some other sense less abstract, matters not. The only point I wish to illustrate is the pure Egyptian quality of the name of this King of Judah, so closely allied both in his politics and in his religion, with the Egypt of his day. His alliance however availed him little. Egypt was always a broken reed to lean on. Esarhaddon came and Manassah was carried away captive to Babylon, where he probably perished;† although the priestly tradition is that he repented, was restored to his throne, and became a pious Jahvist, dying in peace at the

* The language of the hieroglyphics was gradually made a "benefit of clergy" in Egypt itself; and it is more than doubtful whether Herodotus was permitted to get the least insight into it. Diodorus shows clearly that in his day, first century B. C., it was a sealed book to the most curious of the Greeks. One of the most striking examples of this ignorance in which even common Egyptians were kept, is adduced by Krall (in his Manetho und Diodor, Sitz. d. K. AK. d. Wiss. 1880, p. 245). Herodotus found on the roads from Ephesus to Phocœa, and from Sardes to Smyrna, Egyptian monuments which local tradition called images of Memnon, made by Sesostris, on one of which was an inscription in hieroglyphics passing from one shoulder to the other. He gives the following absurd interpretation of it, *ἐγὼ τὴν δὲ τὴν χώραν ὤμοισι τοῖς ἐμοῖσι ἐκτησάμεν*, "I have won the country with my shoulders (arms)," as quite reliable. Knowing nothing of the language, he had the inscription interpreted for him by one of the Egyptian colonists at Larissa (a city not far to the southeast, founded by the Egytian confederates in the army of Crœsus), who, although an Egyptian, knew as little about the hieroglyphic language as Herodotus himself did.

† In 2 Kings 21 : 18, nothing is said about his repentance, but he is buried in his garden Uzza.

age of 68 (664 B. C.); having reigned 60 years, a longer reign than that of any other Hebrew monarch.

"*Amon* his son reigned in his stead."

Nothing more can be asked in demonstration of the Egyptian name of the royal father; the royal son bore the most sacred of all the divine names of the Egyptian Pantheon, AMN, Ammon Ra. Consequently he "walked in all his father's ways and served the idols his father served, and worshiped them; forsaking Jehovah, god of his fathers, and walking not in Jehovah's ways,"—but only for two years; for at the age of 24 his servants slew him; and the populace slew the conspirators and placed Josiah on the throne.

Josiah, the 8 year old son of the murdered Amon, was a pious boy, and a staunch Jahvist King, no doubt through the influence of his mother, Jedidah, daughter of Adaiah of Boscath. Her name ידידה, *Ididé*, "the beloved one," curiously resembles in spirit that of Manassah's mother, *Hephzibah*.

Its resemblance to the pet name of the little Solomon, ידידיה, *Ididié*, "the beloved of Jah," is equally remarkable, especially in view of the likeness which this last bears to such Egyptian names as *Meri-n-Ra*, *Meri-n-Amun*, *Meri-n-Ptah*, &c.

The difference between *Ididé* and *Ididié*, may indeed not have been an actual one; or, may have resulted from the difference of sex. It is, however, very noteworthy that the heathen *Amon's* wife's name does not seem to have included the Jahvist element, any more than did Hephzibah; and therefore, we are left to conjecture that it was bestowed upon her by her loving spouse.

The name of their son *Josiah*, LXX *Ἰωσίας*, יאשיהו, *Jas'ieu*, "whom Jah healed," if this be its correct etymology (from יאש healed), refers directly to Jehovah; and the wonder is that Amon should have given such a name to his child. It is quite possible, however, that the boy was saved from some serious infantile disease by a priest-physician of the native religion, and that the infidel father was superstitious enough to give the national deity the credit of the cure.

On the other hand, great obscurity hangs over the true etymology of proper names ending in U.* And if the Mosoretic pronunciation *Joshiahu* be accepted, another very disturbing Egyptian element enters the name.

*Some of the Egyptian names ending in U seem to have been considered (at least by the scribes of the XVIII XIX Dynasties) as plurals, because they repeated the previous letter three times, or followed it by three strokes (both signs of plural); as in the case of Ra-aa-χeper(u) 71st on the Tablet Abydos; Ra-men-χeper(u) 72nd; Hor-men-Ka(u) 31st; Ra-...Ka(u) 53rd: Ra-neferKa(u) 54th; Hor-nefer-Ka(u) 54th; Ra-nub-Ka(u) 61st: Ra-sha-Ka(u) 63rd.

But in Ra-nefer-Ka-shu-tu, 45th; Ra-nefer-Ka-n-nu, 52nd; Ra-ma-ma-χer-u, 65th (a very remarkable name, involving the symbols of justification, from which, as I have elsewhere shown, the Greeks got their *μακαρῖος*, blessed) the final U is a distinct literal element of the name, or seems to be.

It is true the *h* here is the weak ה and not the strong ח; but that is as open to conjecture as all the rest. If it were written אֹשִׁיחוּ then we have a genitive followed by *aχυ*, as in the case of the name of the Sphinx Hor-m-aχu. Or *χυ* alone, would suggest the name of the Euhemerist Pharaoh *χυ*-n-aten. And the number of names in Egyptian and Hebrew as well as in Sanscrit ending in U, is very remarkable, and deserves a special investigation. It is noteworthy that the LXX Ἰωσία-ς does not express the final *u;* as if the name as known to them was simply *Jas'-Ja'*.. "Jehovah heals." Again there seems no good reason for the transposition of the elements of *Josiah* when compared with *Joshua*, which is written with the יהו not *after* but *before* the verb, and yet is translated in exactly the same way by the etymologists "whom Jehovah saves."

The fact seems to be that 1. We are quite ignorant of the genuine original forms of such proper names; 2. We are equally ignorant of the correct meaning of their elements, even such as they have come to us by tradition; and 3. No sound canon of grammatical interdependence of the elements has been established; and that because exegetical etymologists have been content to study the names embodied in the literature of one people quite apart from the names embodied in the literatures of other nations.

It is very doubtful if the name of the hebrew deity, Jehovah, is at all represented in a multitude of proper names in the Old Testament for the interpretation of which it has been taken for granted, merely on the ground that they were or are supposed to have been hebrew names.

Josiah is a flagrant instance of this uncertainty.

The hebrew history of this monarch's reign is of the highest importance to the student of that chronic war which raged in Palestine between the Jehovah cultus and various other religious rites. His open, powerful and persistent efforts to fix the national mind on one god, Jehovah, is described as commencing in his 20th year (the 12th of his reign). The chronicler says, that when he was only 16 years old, "while he was yet young, he began to seek after the god of his fathers." This would imply that before that he had been an idolater, like those around him. The older historian says nothing of this, and nothing even of the terrible raid which, in his 20th year, the chronicler reports him as making upon the high places of Judah and Israel. The older historian passes over all this and commences his account with what Josiah did in his 26th year (18th of his reign). Both accounts then agree in telling, almost in the same words, how he sent Shaphan, the scribe, to Hilkiah, the priest, to take account of the temple money offerings, and to apply them to the restoration of the dilapidated edifice.

Hilkiah told Shaphan that "he had found the book of the law in the house of Jehovah." Shaphan read it; and read it to Josiah, who rent his clothes in dismay at its contents, and ordered Hilkiah, Ahikam, Achbor and Shaphan to consult the oracle, "to inquire of Jehovah, for

him and the people and all Judah, concerning the words of the book: "for great is the wrath of Jehovah kindled against us; because *our fathers* have not hearkened unto the words of this book, to do according to all that is written concerning us."

Huldah, the prophetess, was the pythoness of whom they sought the oracle. There is no mention of any oracle in the temple itself. There seems to have been no Shekinah; no high priest privileged to ask of Jehovah himself.

Huldah is thus described: "Huldah, the prophetess, wife of Shallum-ben-Tikvah-ben-Harhas,* Keeper of the Wardrobe. She dwelt *in the college* in Jerusalem." 2 K. 22: 14. This is evidently an explanatory gloss of later date.

Huldah's prophecy of peace to the King, and disaster to the Kingdom, then causes a convocation; a solemn covenant between King, people and Jehovah; a complete cleansing of Jerusalem and of the whole land; the utter destruction of all idols, and abolition of strange rites. The story is very elaborate, and fully proves the prevalence of every variety of foreign cultus previously, and the virtual invention of the Passover as a national festival at this time. And it looks as if the whole history of the Exodus were invented on this occasion for the purpose of erecting an impregnable barrier against Egyptian influence and ideas.

However this may be, the Egyptian alliance was so completely broken up, that when the Pharaoh Necho took the field against Assyria, Josiah intercepted his march at Megiddo in the north, and was defeated and slain, in spite of his pious zeal for Jehovah. It was no doubt to explain this astounding calamity, that the story of Huldah was invented and introduced into the annals of the reign, by subsequent historians.

Jehoahaz, Josiah's son, bore the name of a much more ancient King of Israel, son of Jehu.—It is remarkable that *Jehoahaz* is said to have had another name, *Shallum*, שַׁלֻּם, "*retribution*," which was the name of the 15th King of Israel, who slew Zechariah, son of Jeroboam II, and thus extinguished the family of Jehu. It seems perfectly inexplicable that the fanatical Jahvist Josiah should have given not merely one but two accursed names to his son and heir; and that one of these names should have suggested the murder of the man's race who bore the other.—And another remarkable thing is that *Shallum* was also the name of the husband of Huldah the prophetess.—Either such names are merely the inventions of subsequent chroniclers; or, they are mixed up in the history so as to divest them of all personal genuineness; or, they were bestowed without regard to their meanings; or, lastly, their reputed meanings are good for nothing.

Jehoahaz was 23 years old, and only reigned three months after the defeat and death of his father. He is said to have spent these three

* The uncertainty surrounding hebrew private names is exhibited here; for the chronicler (2 Chron. xxxiv, 22) repeats the story almost verbatim, and yet gives this name Harhas חַרְחַס, as Hasrah, חַסְרָה, a totally irreconcilable difference, not to be explained by any ordinary blunder of transcription.

months in upsetting his father's Jahvism, and restoring idolatry. Necho, on his arrival at Jerusalem, sent him a prisoner to Riblah in northern Syria, and made Josiah's brother, *Eliakim*, King, turning his name to *Jehoiakim*.

Eliakim, אליקים, ALIQIM, is supposed to mean "God has appointed him" (Ges.) from קום, to rise, stand; קים, piel, to make rise, stand, confirm, establish &c. If this be so, then why does Gesenius say of אליקא (2 Sam, 23 : 25) "etymology unknown," when it should mean "God has spewed him out," from קוא, to spew out? What is good etymology in the one case should be good in the other.—But a more embarrassing question arises :

Jehoakim (Eliakim) should then mean "Jehovah has appointed him." Now, how is it possible to suggest any motive for an Egyptian King changing his Hebrew vassal's name by substituting "Jehovah" for "El;" especially seeing that he himself worshiped *El* (=RA), and his vassal (so the history goes on to state) hated Jehovah, "as all his fathers had done?"

This again shows that either the hebrew traditional names are wrong, or that their hebrew traditional etymologies are valueless.

It must be noted that Josiah's mother was *Jedidah;* but his brother Jehoakim's mother was *Zebudah;* so they were only half-brothers; and while Josiah was 39 years old, his half-brother, Jehoiakim, was only 25. These 14 years may have made a great change in the hareem of King Amon, and goes far to explain the anti-Jahvism of the younger half-brother.

Undoubtedly polygamy at the court of Judah was the ground cause of the continual revival of anti-Jahvist worships in the history of the kingdom. Josiah's own children could have very little chance for a good education in their father's orthodoxy, surrounded as their infancy and adolescence must have been by female worshipers (open or secret) of Baal, Moloch, Chemosh, Rimmon, Thammuz, Astarte, Neith, and other Syrian and Egyptian deities. It is only surprising that the titles of these deities do not appear in the lists of royal names. Why do they not? Were the mothers deterred from naming their children after the deities which they were permitted openly to adore? That is evidently no explanation. Are we then left to conjecture that the reiterated story of this court idolatry is in the main a mere late priestly tradition, without foundation in fact, and penned for a long subsequent purpose, viz., to account for facts otherwise unaccountable?

Among other nations, Greek, Phœnician, Assyrian, Babylonian, Egyptian, the national pantheon is painted and recorded in each royal nomenclature. The Hebrew annals, both Kings and Chronicles, have this exceptional feature : they affirm that kings and people alike were habitual worshipers of numerous well-known deities, and yet, while they record lists of royal and common names compounded from the name of one

asserted national deity, they record none compounded of the names of the deities said to have been habitually worshiped; except the three or four mentioned in previous portions of this paper.

It seems to me that this fact has been overlooked, and ought to be taken into account in judging 1. of the trustworthiness of the hebrew chronicles, and 2. of the correctness of the exegetical etymologies in our hebrew lexicons.

If it be sound historical argument that the Pharaohs of the III and IV Dynasties were pious worshipers of AMUN-RA, the national deity, because they were named *Ra-neferka, Ra-fu,* * *Ra-tatef, Ra-Shaf, Ra-menkau,*— and if it be a fair inference that *Asdru-bal, Hanni-bal, Ha-milcar* and other Phœnicians were honest and consistent worshipers of *Baal-melcarth,* the phœnician deity,—it seems an equally reasonable conclusion that if the Judæan and Ephraimitish princes had names in which the word Jah or Jehovah can be recognized, they must have been worshipers of Jah, although the chronicles vehemently affirm that they were not.

In other words, historical analogy would teach that the Kings *Abi-jah, Jo-saphat, Jo-ram, Jeh-u* (? Jah-u), *Hezek-jah,* &c., were all alike worshipers of Jah, with Jah's prophets *Sephon-jah, Eli-jah, Jo-el, Isa-jah,* &c., and in spite of the historical denunciation of their alleged idolatries made by the compilers of the Kings and Chronicles of after centuries. If not— then we are compelled to assume that the deity name, Jah, is wrongly identified in their proper names.

It is certainly a remarkable thing that the kings who are traditionally reported as founders of the Jehovah worship, Samuel, Saul, David and Solomon, do *not* carry the name of the deity in their names.

And the same argument may be reasonably employed in investigating the antiquity of the Jehovah worship, in view of the startling fact that none of the patriarchal names exhibit this element: neither Heber, nor Terah, nor Abram, nor Sarah, nor Ishmael, nor Isaak, nor Rebekah, nor Esau, nor Jacob (Israel), nor a single one of their numerous reputed offspring, Reuben, Simeon, Levi, Judah, Zabulon, Issachar, Dan, Gad, Asher, Naphtali, Joseph, Benjamin, Eliphaz, Reuel, *Jeush,*† *Jaalam,*†† and Korah. It is needless to say that none of the "dukes of Edom" (Esau's children), Teman, Omar, Zepho, &c. (Gen. xxvi: 15), contain Jah. But it is worthy of deep consideration that Jacob's descendants do not seem to have been called after the "Lord God of their fathers."

Judah's sons were called Er, Onan, Shelah.

In the next generations come: Pharez, Zerah, Hezron, Hamul, Zimri, Ethan, Heman, Calcol, Dara, Achar, *Azariah* (son of Ethan, 1 Chron. ii: 8), Jerameel, Ram, Chelubai, Amminadab, Nashon ("prince of the Beni-Judah" 1 Chron. ii: 11), Salma, Boaz, Obed, Jesse, and his seven sons,

*Supposing that the barred disc of the tablets, *Shu*, is a mistake for the plain disc, *ra*.

†יעיש JOIS. ††ילם JOLM. But these names commence exactly alike, but have received from the Masorites different punctuation, for no apparent reason. Neither of them show any trace of Jah.

Eliab, Abinadab, Shimma, Nethaneel, Raddi, Ozem, David, with their two sisters *Zeruiah* and Abigail.

Of all these names, Azarjah and Zerujah alone contain the Jah (and the very late date of the list makes these suspicious), yet this is the royal line of David, "the man after Jah's own heart," the supposed designer of the temple, and the supposed inventor and establisher of the liturgy of Jah.

It may be said that the negative argument is of no weight because it proves too much; for neither does this long list of names exhibit the title of any other deity. In reply it may be said:

1. That the absence of other deity names is not certain until the personal names are investigated in light of the comparative mythology of that day; and

2. That several of them do contain the name of the Assyrian and Egyptian deity Bel, El (=Ra:) viz. Ishma*el*, Isra*el*, Reu*el*, Hamul (?), Calcol (?) Jerame*el*, *El*iab and Nathane*el*.

Of Hezron's descendants in the line Caleb: Jesher, Shobab, Ardon, Huz, Uri, *Bezeleel;* in the line of Segub, Jair, Ashur, Tekoa; in the line of Jeremeel, Ram [Bunah, Oren, Ozem, *Ahijah,*] Onam [Maaz, Jamin (c-Benjamin), Eker,] Shammai, [Jada,] Nadab, [Abishur, Ahban, Molid, Seled,] Appaim, Ishi, Shéshan, [Ahlai, Jether, Jonathan, Peleth, Zaza,] Attai, Nathan, Zabad, Ephial, Obed, Jehu, *Azariah*, Helez, *Eleasah*, Sisamai, Shallum, Jekamiah, Elishama, extending through 21 generations =600 years, *i. e.* down to the captivity of the ten tribes—only two have the word Jah, and both are comparatively late, *Abijah* and *Azariah*.

A valuable bit of information for our purpose is given in the following words (1 Chron. ii, 34) "Now Sheshan had no sons, but daughters. And *Sheshan* had an Egyptian slave, his name *Jarha*. And Sheshan gave his daughter to his slave Jarha to wife; and she bare him *Attai*. And Attai begat Nathan;" &c., as above.

Here, if any where, we might find pure Egyptian names; שֵׁשָׁן S'é-S'a-N, יַרְחָע IRHO, עַתַּי OTI.

A most remarkable coincidence in fact occurs. This Sheshan father of Attai corresponds so closely and unexpectedly with the *Shesh* and *Atta* of early Egyptian story, that the reference of one to the other in some unexplained and perhaps inexplicable way seems inevitable. The Egyptian part of the coincidence is referred to in a recent memoir by Dr. Jacob Krall* "On the composition and fate of Manetho's History;" where, after recounting the evidence of the mythical character of the lists of names of the Kings of the 1st, 2d and 3d dynasties, preceding the 1st King of the Karnak tablet (probably the first really historical King) Snefru (1st of the 4th dynasty of pyramid builders) he goes on to say:—

"We are moreover in a condition to suggest the origin of these mythical accounts. A series of chapters (of the Ritual) and especially powerful formulæ were relegated by the priests to the days of their most ancient Kings. Chapter 130, e. g., to the reign of Husapti (υσαφειδης) I. Dy. 5th

*Sitzungsberichte der K. AK. der Wiss. Phil. Hist. Cl. XCB, Juli 1879, p. 130.

King; Chapter 64, to the reign of Menkaura (builder of the third pyramid).*

"We read, again, in the Medical Papyrus Ebers of a hair salve prepared as long back as by *Shesh* the mother of *Teta*, (TTA) apparently the *Ἀθοτις* of the lists, 2d King of the 1st Dynasty," the immediate successor of Menes, &c.

The tablets of Abydos and Saqqara give the following combined list of names of the Kings of the first three dynasties: Mena (Menes), TeTA, ATeTh, ATA, Kenkenes, Husapti (Sapti), Meribapu, Semempses, Qebuhu, Butau, Qaqeu, Ba-n-neter, Watnas, Senda, Hetefa, TTAA (T'atai), Neferqara, Sokarneferka, Nubkara, Sar, Sar-TeTA, Huni. Snefru.

It will be seen that TTA occurs with slight variations five times in this list of 23 Kings. The hair-ointment is assigned to the mother (*Shesh*) of the first one. I give little weight to Krall's etymologies of these names, although he accepts them as "ganz abschliessend festgestellt" by Lauth, in his Manetho (p. 87). I prefer to refer them all (as mere modifications) to Tat, the sacred symbol, Nilometer, or what not, used incessantly in the priestly literature and on the monuments with numerous meanings more or less radically different. But I wish to insist here on the striking fact, that the value of this famous verb and known root of Egyptian literature could not very well be more highly guaranteed and illustrated than by its being used alone and without any other compounding element to manufacture (whether historically or traditionally or mythically is a question of no moment here) the personal names of *five* out of 23 of the most ancient Kings.

Its value is further shown by the fact that it entered as a compound into the names of many other Kings (like Ra·tat·f, Tat·kara, &c.) of succeeding dynasties.

Its highest value is exhibited in the name of the special god of the clerici, clergy, clerks, scribes, the god of learning, *i. e.* worship, *Thoth*.

But it appears among the names of the egyptian nobility or bourgeoisie (for it is hard to distinguish between these classes, distinct as they become in modern times); as, *e. g.*—In the tombstone of a gentleman of the Ancient Empire preserved in the Boulaq Museum at Cairo (No. 71, Magazine V, Mariette's Aperçu.), the legend runs, that his name was, ATA; his father's ....*ua*; his mother's *Neb·t*; and his son's *Sebek-nefer*.

Taking this private name (in the 5th dynasty?) ATA, and comparing it with the royal names ATA, ATeT, TeTA, and TeTAi of the 1st and 2d dynasties, we can not be surprised at the appearance of the name ATI, in 1 Chronicles ii: 34, *given, as it is there, to the son of an Egyptian*, the slave of one of the descendants of Judah. But the marvel is that the slave's wife's father should have the egyptian sounding name *Sheshan;* and that the Ebers Papyrus should call the mother of the pharaoh TTA, *Shesh!*

To return to the list of early names in 1 Chron. ii: 17.

*4th King of IV Dy. If Snefru were the 1st. But if Snefru was the last King of the III D then Mycerinos was 3d King of the IV D.

Although one of Jesse's nine children (notably one of his two *daughters*, and not one of his seven sons) *Zeruiah*, seems to carry the *Jah*, it is remarkable that it does not appear in the names of her three sons, *Abishai*, *Joab* and *Asahel*, עשה, יואב, אבשי. (ABSI, IUAB, OSEAL) in the first and second of which *ab*, father, is the main element,* the *si* (shi?) of the one and the *iu* of the other, being of unknown sense; for *iu* = Jah, (Jahveh) there is no evidence whatever.

The third name, *Asahel*, is given in our modern hebrew text as a compound name, with a hyphen between the OSE and the AL, evidently inserted to support a popular or Masoretic etymology עשה-אל, "God made," *i. e.* him; or "God works" in the indefinite or abstract sense.†

The other sister of David, Abigail, married Jether the Ishmaelite, and bore *Amasa*, whose name has a pure Egyptian ring; and, considering the relations of the desert to the delta, we should expect to find plenty of Egyptian elements in Ishmaelite nomenclature. Amasa is written OMSA, which might easily be the Judæan pronunciation of *am-se*, "(his) mother's son;" but a vague conjectural suggestion like this, however poetical and even proper to the circumstances, can be of no scientific value.

The grand fact stands out visibly, that in the family circle of David, the man after Jehovah's own heart and the supposed instituter of Jahvish, there is but the one trace of the existence of a Jehovah worship, viz., in the name of one of his sisters, Zeruiah, צרויה, and that is doubtful for good reasons.

That there were two philological elements in Judæa is curiously illustrated by the fact that the unfortunate son of Saul and rival of David is named in one document (1 Sam. xiv: 49), ISUI, ישוי (Ishui); and in another document (2 Sam. ii: 8) a translation of *isui* is made into AIS-BST איש-בשת (Ish-bosheth) "man of folly." *Ishui* was his Ephraimite or Hebrew name, and *Ishbosheth* was the nickname given to him in the camp and at the court of the men of Judah. Had it occured first in Chronicles, we would be compelled to consider it a priestly term of reproach of the times of Ezra.

Jedidah was a similar nickname given to *Solomon* at his birth by Nathan the prophet, but from an opposite (Jahvist) stand point. It occurs in one of the older and more reliable documents, 2 Sam. xii: 25, and is probably one of the earliest genuine instances of the actual establishment of the Jehovah cultus, and goes far towards removing our doubts of its existence in the times of David. ידידיה (IDIDIE,) can hardly mean anything else than "Jehovah's darling;" (compare *Jedidah* "Her beloved," the proper name of the mother of King Josiah; 2 Kings, xxii: 1, and *Jedideka*, "thy beloved ones" in Ps. 127: 2. There is but one suspicious circumstance, viz., that it is a pretty fair pun upon the name of the baby's father, *David*, דוד (DUD) or as it is written also דויד (DUID) Hosea iii: 5.

* Unless the Egyptian *ab*, libating priest be preferred; as in the name Ka-ab of χufu's son, (6, D. § 151, 155 MS.)

† Another עשה is given by Gesenius as an absolute root meaning "to be hairy, rough, shaggy." c. Arabic. Hence proper name *Esau*. But the probability is that the whole story of Esau's hairiness was worked out of this late etymology, itself entirely worthless.

This name, *David*, first appears in 1 Sam. xvi, 18, in Jewish history, where it is written DUD, as is usual in the earlier documents, gradually changed to DUID as time went on. Its early form is important, because it is identical with the Hebrew word דוד, DUD, a *pot, kettle, basket* (Job, 1 Samuel, 2 Kings, Jeremiah, Psalms, 2 Chronicles) from the connection of which with *boiling over fire*, came a verbal DUD, *to boil, to be agitated, to love;* the plural noun DaDIM, *sexual love* (loves); the singular noun, *a love, a friend, an acquaintance;* and the title, DUDE, *aunt*, father's sister or uncle's wife. Hence DUDI (*my delight*, Roy), the mandragora or love apple, Gen: xxx, 14, Cant. vii: 14, and DUDU (*his beloved?*) a proper name (Roy).

AEB is the regular hebrew verb *to love;* χMD means to love covetously; χNN, to love with compassion; χSD (עסד), to love with benevolence, to be gracious; χPZ, to love with joy and delight; χ'SQ, to love with esteem, as a companion; IDD, simply TO LOVE, to be pleased with, *i. e.*, without sexual emotion; IDO, to love with reverence based on knowledge (a mere poetical use); IRO, to love with worship (ditto); OGB, to love lewdly; RχM, to love as God loves and pities men; S'CB, to lie with.

David's children's names are given in an old document, 2 Sam. v: 14, and in a much later one, 1 Chron. iii: 1, thus:

1. Born in Hebron:—1 Chron. iii: 1.

Amnon,	אמנן of Ahinoam of Jezreel.
Daniel,	דניאל of Abigail of Carmel.
Absalom,	אבשלום of Maachah, princess of Gesher.
Adoni-jah,	אדניה of Haggith.
Shephat-iah,	שפטיה of Abital.
Ithream,	יתרעם of Eglah, "his wife."

2. Born in Jerusalem:—

2 Sam. v: 15.		1 Chron. iii: 5.	
Shamuah,	שמוע = שמיא	Shimeah,	Of Bathshuah (Bathshebah) "four."
Shobab,		שובב Shobab,	
Nathan,		נתן Nathan,	
Solomon,		שלמה Solomon,	
Ibhar,		יבחר Ibhar.	
Elishua,	אלישוע=אלישמע	Elishama.	
		אליפלט Eliphelet.	
		נגה Nogah.	
Nepheg,		נפג Nepheg.	
Japhia,		יפיע Japhia.	
Elishama,		אלישמע Elishama,	
Eliada,		אלידע Eliada.	
Eliphalet,		אליפלט Eliphelet, "nine."	
		תמר Tamar, "their sister."	
		"Besides the sons of his concubines."	

It is evident that the second list in Chronicles is a bad copy of the list in 2 Samuel, or of some document the source of both lists, from the blunder of the scribe in *repeating Elishama** and *Eliphalet*. Where the chronicler got his *Nogah* can only be conjectured from its distant resemblance to the following name *Nepheg*.

How many other errors of transcription there may be in both lists no one can now find out. But it is evident the *Jah* does not occur in any one of the names of the eleven children of the reputed founder of the *Jah cultus*, said to have been born to him in Jerusalem, where he is supposed to have prepared the site of the *Jah temple*, its erection being only prevented by the superior influence of the *Jah high prophet* Nathan, whose name one of his children in the Jerusalem list bore. The meaning of this obstruction has been much debated. Shiloh in Ephraim had an ancient prescriptive right to the Egyptian *Ark of the Exodus;* and *Nathan*, its then president prophet, foresaw the rupture which actually ensued when the Ark which belonged to the *Beni Israel* was taken to glorify the *Anshi-Judah*, and the provincial Baal-Apis worship of the north was swallowed up in the metropolitan Jah worship of the south.

Nathan, נתן, "he gives," "he gave," is the orthodox etymology of the name both of David's son and of his tutor, the old prophet of the ark at Shiloh.

I propose a very different and purely Egyptian etymology :—*Neter-hon*, the commonest of all the titles on the monuments. Its adoption by the prophet of Shiloh would be of unquestionable propriety. The following examples will suffice to explain its use in the hieroglyphic legends :—

On a stele, found in the Serapeum, and now deposited in the Louvre, *Psametik-mnχ* calls himself :—"Prophet of Isis, lady of the Pyramid, Osor-hapi, and of Hor-m-aχu the great Sphinx," and then adds the following additional titles to his name :†—

These were the three earliest Pharaohs of the Fourth or Pyramid building dynasty, and to every pyramid there were consecrated sepulchral rites and a resident priesthood, as is the case in all Catholic countries now, priesthoods being invariably attached to churches built over tombs, with shrines for the worship of dead saints, martyrs and royal benefactors of religion. This title *Neter-hon* was in constant use from its earliest appearance 3000 B. C. down to the conquest of Egypt by Alexander, 332 B. C. and later. It was exceedingly common in the time of David and Solomon ;

* This is, however, not a repetition, but a misreading of *Elishua* (ב for ע) in the other list.

† The absence of any genitive form is characteristic. It may be used as an argument for the archæic character of such hebrew names as *Ab-salom*, instead of *Abi-salom*.

and if an Egyptian at Solomon's court were to pay his respects to *Nathan*, he could only do so with propriety by addressing him as the great *Neter-hon* of the Ark of the Covenant of God, and of the shrine at Shiloh. There was no other phrase in the Egyptian language which he could use with equal propriety according to custom.

Neter-hon means *Divine prophet*, the hatchet standing for God, and the second symbol for prophet. Translated into Hebrew it would be *El-shaphat* (shophet). It is not a little remarkable that the fifth name on the list of the six sons said to have been born to David (each of a separate wife) in the old capital of the south, Hebron, is:—

Shephatiah, "the prophet of Jah." But this name is not more significant of *Jahvism* in David's family *at Hebron* than the name of his fourth son

Adonijah, "My lord, Jah;" and it would be folly to attempt to find any foreign etymology for so pure and purely orthodox a Jewish compound word.

Absalom, "father [of ?] peace" is as easily recognized, in its Hebrew dress as Melchizedek "king of righteousness," but—

Daniel, *Ammon*, *Ithream* are meaningless; with a suggestion, however, in favor of—

Dani-el, "Judge of [for] God," therefore equivalent to *Shephatiah*. (See Ges.)

Ithream, "He makes abound the people" (Ges. suggests "abundance of the people") like the various Greek names ending in λαος, and δημος:—*Archelaus* (people's ruler), *Aristodemus*, *Laodamia*, *Laodice*, *Menedemus*, *Menelaus*, &c.

Amnon, "The faithful," seems allied to Amen, *Amnah*, verity, a covenant, *Amnon*, verily. Although the root of this Hebraism is undoubtedly the AMN, "stability," of the early egyptian monuments, there is no need of seeing in this name of the eldest son of David any *direct* reference to its Egyptian source. But it is permissible to notice the curious (if entirely accidental) coincidence, that this first born of the long and splendid lineage of David, the virtual founder of the Jewish monarchy and Jewish religion, happens to bear the very name assigned not only to the greatest of all the gods of Egypt, but also to the first monarch of the first dynasty, MNA; the establisher of monarchy; the head of a splendid procession of rulers, among which one at least gave his daughter to Amnon's brother Solomon to be his queen of queens.

One more word about the Egyptian train of ideas concealed in the Hebraic nomenclature.

In Zechariah vi: 11 to 13 occurs a remarkable reference to Egyptian titles and customs, in a confessedly difficult passage involving the famous name of the second Moses—*Joshua*.

The prophet writes: "Take silver and gold and make crowns, and set them on the head of Joshua the high priest, and say to him: Thus saith Jehovah of hosts: *Behold a man, his name* BRANCH (*Zemach*) under

whom it shall sprout;* this one *builds* (*bana*) the temple of Jehovah. This one *shall build* (*ibneh*) the temple of Jehovah; and this one shall *wear* HOD, and *sit and rule on his throne.*"

V'hua issa hod; "*and this* (man) *shall wear* הוֹד, *majesty,* splendor, beauty, brightness, (often coupled with HDR, ornament, decoration, splendor, pomp, as in Ps. 45: 4) used of Kings, 1 Chr. xxix: 25, &c., and of a voice Is. 30: 30, Job. 39: 20. Here in Zach. it must mean some regal insignia, a crown, or diadem.

Now this hebrew word HUD corresponds to HT the *white* crown of Upper Egypt, (TSχR being the name of the *red* crown of Lower Egypt,) and to P·S·χN·T the combined crown of Upper and Lower Egypt, (p = the egyptian article; s = the formative, by which nouns are made verbs, see below, and also the causative; t = a final, often not radical, and not certainly radical in this case).

The *double crown* has for its root χN= חֵן, חר, חזר, in which form it does not appear in hebrew; (for, חר means *one; sharp, to be sharp;* and חור is to riddle, propose a riddle (Judg. 14: 12); חידה an artifice, a riddle, parable, proverb;) unless in the side meaning חרה to *rejoice;* cognate with חֵן beauty (Job. 41: 2, spoken of trappings, ornaments).

The *white* crown of Upper Egypt, the crown of the great Middle Empire (XI, XII Dy.) the crown which carried the royal emblem the Uræus, or Cobra, on its front, the crown of Thebes, the Up-country, the Upper World, was called HT, (not χT,) and corresponds to the הר or הור of Zacharias.

The exact correspondence between the Egyptian and the Hebrew is manifested by the fact that the root *het* (spelled with the globe standard and snake) carries the general meaning of "brilliant, lightening, bright and white." (Brugsch Dict. page 1015.) Sometimes the solar disk with three descending rays is the ideograph; and in one passage (Leps. D. iv, 48, a) *Ra ur s·het χeperu hi ti asep hi ma senen-f,* (with *ra* after the crown and after *asep*) "*the governing sun illuminates* (*s·het-ra,* makes white or bright) *all things, so as to give to exhibition* (bring out to view) *their forms,*" we have an important suggestion of the *causative* force of the *S* in the name of the double crown *p·s·χnt.*—This *het,* followed by nub (gold) means "silver," *i. e.,* white gold, &c.—The Egyptian way of spelling the crown with the standard, t, and the figure of the crown, shows how they meant to intensify the ideas 1, of ornament and 2, of dignity.

The Egyptian simple letter *h* (the fret) in this *het* corresponds to the hebrew ה; but there is one striking analogy which shows that it is transmutable also into ח; for, the Egyptian word *HANA* (followed by a sit-

* Phillippson.—Dewette translates it differently: "who shall sprout up in his place." I think it plain that this sentence is an interpolated gloss, or attempt to explain the meaning of the word Branch *zemach;* but it is of no importance here, because the meaning "branch" for zemach is accepted, both as verb (Gen. 2: 5, 41: 6) and noun (Gen. 19: 25, &c.).

ting man with his hand to his mouth) meaning *velle, placere*, s'il vous plait, s'il est permit, (Brugsch, Dict. p. 903), *i. e.* "by your favour" "by your gracious permission," "may it please your gracious majesty," &c., corresponds exactly to the Hebrew χN (חֵן) *grace, favor* and חָנָה to *protect*, defend, encamp, surrounded, dwell, reside.

There is therefore no obstacle in the way of comparing the HUD, which Zachariah prophesied that the High priest Joshua should wear as Lord of the new Temple, directly with the HeT, the white crown of Upper Egypt, if not with the *pshent* of the whole Kingdom.*

But this is not the most interesting point in my discussion of the passage in Zecharias, although it bears upon its general Egyptological character. The main point is the use of the word *Zemach*, "branch," and its reference to a late high priest bearing the ancient name Joshua.

The Hebrew tradition, adopted by the Christian Church, saw in the term *Zemach*, Branch, as used by Jer. 23 : 5, 33 : 15 and Zech. 3 : 8 and Thes. 6 : 12, the Messiah, as offspring of David and of God ; while its use by Isaiah 4 : 2 is more doubtful, as Genesius explains.

1. I wish to call attention, first, to the poetic alliteration of the sentence in Zechariah : *Zemach shemo*, "*Branch*," (is) *his name*. How far this alliteration availed in causing the selection of the word, I cannot tell ; but this kind of elegant punning is, as all readers of the hebrew scriptures know, one of their commonest features, and is often a great help in exegesis. It gave rise to a good deal of the historical etymology of proper names.

In light of this well known fact it cannot be uninteresting to notice that the term *branch*, or *offspring*, or *child* (applied by the men of the synagogue to the expected Messiah, who should rebuild the temple, and set up his throne) corresponds exactly to the Egyptian etymology of the name of the original Messiah, Moses, *Child*.

The hebrew traditional etymology of the name Moses (Ex. 2 : 10) was evidently constructed on the story of his infancy ; "for I have drawn him out of the water" (ci m'n h'mim m'shithu). And the Egyptian colony of Jews to whom we owe the old greek translation, spelled the name MS'E in a complex manner, μωυσῆς, apparently for the purpose of justifying that etymology, and introducing into it the idea of water.

But in so doing they had to neglect the real point of the etymology in Exodus 2 : 10, where the participle "*being drawn out*" is the only word which carries the etymology.

The Egyptian Jews could find nothing in coptic meaning "being drawn out" to suit them, and had to use the coptic words for "*water*" and "*to save.*" Hence Josephus (Ant. 2. 9. 6 ; cont. Apion 1. 31) and Philo (2. 83) considered the name Moses to mean "*saved,*" not "*drawn out of*" the water.

*Other Hebrew relatives can be found in הֵד. *hêd*, a shout and הוּד. to shout with joy ; in הֵן, *hên*, lo, behold (a shout); and הֵנָּה (fem.) *they*, *i. q.* behold them there!

Other and more modern writers follow a somewhat different track by translating Moses, "*the Preserver.*" For while the writer of Exodus prefers the etymology in its passive form and explains that Pharaoh's daughter called him Moses because she had drawn him out of the water, —the writer of the later chapters of Isaiah (63 : 11) shows that a very different traditional etymology existed in his time, (or in his own mind perhaps), and one wholly incompatible with the other. "*Then his people bethought them* of the old days of Moses, (or, *then Moses' people bethought them of the old days*). Where is he now who once *led* them (or *drew* them) out of the sea, with the shepherd of his flock?" &c.

It is unprofitable to follow further these traditional attempts to explain the name Moses ; or rather the hebrew word *M's'h*, which bears the same relation to the greek form Moses, or Mōuses, that the egyptian name of the first pharaoh M'na does to its greek form Menes.

We have the same liberty to go to the egyptian dictionary as Josephus or Isaiah or the unknown author of Exodus had ; and when we go there we find the words Mas and Massis not only meaning *child* and so used in prose and poetry, but employed as a proper name, either alone or in composition. There was an entire dynasty of Kings each of which bore the name Ra-Mes, and Ra-Messis, "child of the sun." And those who accept the account of Moses place the date of his birth precisely in the reign of the most distinguished of these sovereigns, Ramses II, the greek Sesostris, about 1400 B. C. But the egyptian records tell us that Mass, child, was not an uncommon name, worn by common people and by some in high official position. Pharaoh's daughter could not give a more appropriate name to the boy whom she had adopted as her *child.*

2. It can hardly be a coincidence that both the lawgiver and father of the nation to whom the Hebrews looked *back* with awe and gratitude, and the great deliverer and king of the nation to whom they look *forward* with hope and almost divine worship, should have borne such similar names as Moses and Messiah. In Hebrew the difference between MSH' and MSH' by which *Moses* and the *Messiah* (or the verb to *anoint*) are designated, is merely the difference between a soft and a rough breathing. On the other hand, if Moses meant *child,* and the Messiah was called *Branch,* offspring, the community of ideas becomes complete.

3. The passage in Zechariah has another attraction for the egyptologist. The prophet may and probably did suppose that Joshua, the high priest of his day, was the Messiah, so long expected, and may have called him *Zemach,* the Branch or Offspring (of David) in that hope ; but it was as high priest that he glorified him, saying *Zemach s'emo,* Branch is his name. Now this hebrew word *S'm** is curiously enough the word for the high priest of Memphis in the hieroglyphics. (Brugsch. p. 1221.)

It is written simply *SM, e. g. Sem Ptah,* chief priest of the god Ptah ; *nenek sctem em ariuf,* I, the chief priest among his own people ; &c.

* Masoretic. It may have been *sem.*

Sem written with the bread trough and a boat, is given (in a legend by Lepsius) as the name of a sacred bark.

Sem preceded by a hatchet or other symbols of forward movement (like the bread trough when carried on the head, or the phallus) meant "to present an aspect, to appear, to show oneself, to manifest oneself like a god," also "to show the way,* to point out, to lead." It therefore strictly comports with the meaning "high priest" in both an active and a passive sense.

Sem with the demonstrative of a man with his hand to his mouth, carried the idea still further, viz., to celebrate, to praise, and to bestow a benediction, *i. e.*, to exercise the three functions of a high priest.

Some years ago I saw reason for deriving the greek *συμβολον*, a symbol, from the phœnician *Shembaal*, translating it simply "name of Baal" in the sense of that which represents Baal, or more generally *a divine representation*, or *sacred sign*. This conclusion was supported by the Egyptian use of the word, as above described; as well as by the important use of the same word in the hebrew writings: *Shem Jahveh*, the "name of the Lord," *i. e.*, his representative in human speech, worship, and energy.

If now we return to the archaic history of the Jews, we find the name *Samuel* applied to the most distinguished personage of the times intervening between Moses and Joshua, and David and Solomon,—a personage reputed to be a priest prophet of the highest rank, and, in fact, the originator of that "School of the prophets," that caste of Jewish society which most closely corresponds to the caste of the scribes of Egypt; no doubt more or less modeled after it; and always more or less affiliated and in correspondence with it at the short distance of a few days' journey.

Samuel, שמואל, *Σαμουηλ*, dedicated before birth to the tabernacle, by his mother *Hannah*, was named with some direct reference to his dedication. Had this been to a god who had already revealed himself by his name Jah, *this* child of all others would have had *Jah* in his name. Instead of that the general word for god, *El*, evidently stands in his name; and, if the word be hebrew, the other element *Sam*, *Shem*, *Sam-u*, can be no other than שם "name." But whether the whole word can be translated "His name, El" or not is the question.

At first glance this seems a violent metaphor, of which even such savages as the hebrews of that day could not have endured. But after all, it would only be a very contracted form for "His name dedicates him to El;" or "He is named after EL."

But who was this El? for we cannot imagine the abstract God to be meant, any more than the pantheon Elohim.

What forbids us on the one hand to regard this particular El, as the Egyptian La, or Ra, or on the other hand as the Assyrian Bel, or "Shining Bar?" In fact, Ra, El, Bel, Bar and Baal were all one.

I propose, therefore, the etymology *Sam-Wal* שמ-ואל, Shem Wal=

* With the ideograph of a road and pair of legs, it meant "the way or path" (well known to all and easily followed). Compare the allied latin verbs DICere, DOCere, DUCere, showing the connection of the Bard and Baron ideas.

Shem Baal, instead of שמו-אל, Shemu El = His name El; and support it by the following arguments:—

1. The harshness of the construction if *Shem-u* be translated His name; to say nothing of the lack of analogies for such a composition. What is there in Greek for instance like *Ονομαθεος* or *Ονομαθευδατος*, or *Ονομαυτουθεος*, or any possible such construction for a personal name? We have Numa, Numitor, and Numenius, suggestive of *Numen*, but not a latin proper name compounded with *Nomen*. Such a name as Nomentanus, like Numantianus was geographical and not mythological.

2. Of the same age as *Samuel* was *Samson*, שמשון, in which etymologists find *Shemesh* the Sun, and *Un* or *On*, untranslatable, but probably meaning *light*.* But if *Samuel* means "Name of him El," Samson should mean "Name S'un, or S'on." (C. Chiun, Amos 5: 26.)

3. *Shem* in hebrew means *Sign*, like *σημα* in greek. Some look on it as an abbreviated שמע, ShMO, *to hear, something heard*, which the LXX not unfrequently translates by *ονομα* (Gesenius). Hence *Shem, name*, ex. *Shem* Jehovah, Name of the Lord, &c. But if the meaning "Name" be inapplicable in *Samuel*, the meaning "Sign" is very applicable; and we could not have a better etymology than "Image of El" for the boy prophet. But this necessitates the change of El to Vel, or Bel; and "Image of El," to "Image of Bel;" in other words, the greek *Συμ-βολ-ον*, borrowed from the Shem-Baal of the Phœnician traders.

4. We have this form contracted in the curious phrase פסל הסמל, *pesel ha* SEMEL, "Statue (cutting) of likeness" literally, "Statue portrait," "carved image," "stone symbol," of Deut. 4: 16 and 2 Chron. 33: 7; also Ez. 8: 3, 5.

And in another equally curious form שכאל, the left, the left side, the *north;* when we remember that the ancient pantheon sat in the sides of the north, in the hill of the north; while the Sabæon mythology had for its symbol of symbols, the pole star and the Great Bear.

Before leaving the subject, I would suggest the possibility of an etymology from צוה TsVE to command, rule, a precept; compared with a very characteristic SM *to command* in Egyptian (see Birch in Bunsen, Eg. V, pp. 508, 509, and I, p. 567) *Sem*, chief, deputy; *Samsu*, king's deputy, provincial nobleman, represented by the spade, and a man holding the *suten* or royal plant in his right hand. Hence *Sam·t* to establish.† Another Hebrew form of the word is שבע, S'BO, not radically differing from the other; and a third form, also radically identical with the other two, and equally referrable to the more ancient Egyptian form, is שפט S'PT, meaning to command, not as a deputy, but as a judge. And in this we find ourselves returned to *Samuel* as the great Judge in Israel.

*AUR is light; AUN—On, the city of the Sun in Egypt, called by Jeremiah (who went to Egypt) Beth Shemesh, house of the Sun; by the greeks, Heliopolis, city of the Sun; by the Arabs, fountain of the Sun (mistaking AUN for AIN); in Coptic, *ouein, oein, oubini*, light.

†Curiously enough the same word was used for a conspirator, with various ideographs signifying punishment for malfeasance in office.

Stated Meeting, June 17th, 1881.

Present, 5 members.

Vice-President, Mr. E. K. PRICE, in the Chair.

A letter accepting membership was received from Mr. James A. Murray, dated Mill Hill, Middlesex, N. W., England, May 7, 1881.

A letter acknowledging the reception of his diploma was received from Mr. C. H. F. Peters, dated Hamilton College, Clinton, N. Y., June 14, 1881.

A letter acknowledging Transactions Vol. XV, No. 3, was received from the Smithsonian Institution.

Permission was granted to Major Jed. Hotchkiss, of Staunton, to use a wood-cut.

Acknowledgments were received of the receipt of Transactions, XV, No. 3, from the Smithsonian Institution, and of Proceedings, from the Austrian Acad. (104, 105); Bavarian Academy (104, 105, 106; List); American Statistical Association (105, 106, 107; List); Connecticut Historical Society (108); American Antiquarian Society (108); Boston Public Library (108); New Hampshire Historical Society (108); Essex Institute (108); Rhode Island Historical Society (108); New York Historical Society (108); New Jersey Historical Society (108); New York Hospital (108); American Ethnological Society (108); Astor Library (108); Maryland Historical Society (108); H. Phillips, Jr. (108); Pennsylvania Historical Society (108); J. F. Carll (108); J. H. C. Coffin, W. B. Taylor, Washington D. C. (108); Georgia Historical Society (108); R. Peter, Lexington, Ky. (108); J. M. Hart, Cincinnati, Ohio (108).

Letters of envoy were received from the Academies at Vienna and Munich, Breithoff and Härtel, at Leipsig; the Holland Society, at Harlem; Musée Guimet, at Lyons; N. G. d. O., at Altenburg; the Manchester Literary and Philosophical Society, and the Department of the Interior of the United States, Washington, D. C.

Donations for the Library were received from the R. and I.

Academies at St. Petersburg, Berlin, Vienna, Munich, Göttingen and Rome; from the Societies at Görlitz, Leipsig, Offenbach, Altenburg, St. Gall, Harlem, Manchester, Glasgow, Quebec and Montreal; from Professor William Whitney, from Leipsig; the Archives at Nijmegen; the Geological and Horticultural Society at Berlin; the Zoölogical Garden at Frankfort; the Paris Geographical Society; Revue Politique; Annales des Mines; Museum of Natural History; Bureau of Longitudes; Observatory; Anthropological Society; M. Claud. Jannet; from the Academy and Geographical Society at Bordeaux; from the Observatories at Prag, Munich, San Fernando, Oxford, Stockholm and Washington; the Trigonometrical Survey of India; the Department of Mines; the Royal Society of New South Wales and Archibald Leversidge, at Sidney; the Inspector of Mines, Melbourne; the Royal Institution of Great Britain, Royal Astronomical Society, Royal Geographical Society, Geological Society, Royal Asiatic Society, Editors Nature, the Chemist's Journal, Steven's Historical Collection and Journal of Forestry, at London; the Natural History Society of Northumberland; the Radcliff Observatory; the Literary and Philosophical Society, at Manchester; the Philosophical Society, at Glasgow; the Royal Geological Society of Ireland; the Literary and Historical Society of Quebec; the Canadian Naturalist; the Museum of Comparative Zoölogy, at Boston; the American Journal of Science; the Peabody Academy of Science; Professor E. D. Cope, the Franklin Institute, the Medical News and Journal of Pharmacy, Thomas Meehan, Henry Phillips, Jr., at Philadelphia; the Peabody Institute, at Baltimore; the Chief of Engineers U. S. A., the Smithsonian Institution, Bureau of Education, United States National Museum, Rear Admiral John Rodgers, Edward C. Pickering and Albert S. Gatchet, at Washington; from Major Jed. Hotchkiss; the Geological Survey of Kentucky; Wabash College; the Historical Society of New Mexico and the Ministerio de Fomento, in Mexico.

Professor I. C. White communicated a paper entitled "Notes on the Geology of West Virginia; a rectification of the Sec-

tion made by Mr. Howard Grant Jones, and published, under the title, Notes on the Cumberland or Potomac Coal Basin," in the Proceedings, No. 107, pages 111 to 116.

Professor P. E. Chase communicated a paper entitled "Photodynamic Notes, III," including "A Series of Natural Standard Units for gravitating, luminous, thermal, electric and chemical comparison."

Dr. George A. König communicated a paper "On *Alaskaite*, a new member of the series of bismuth sulpho salts," as a "contribution from the University of Pennsylvania."

Pending nominations Nos. 934 to 936 and new nominations Nos. 937 to 940 were read.

Permission was given the Librarian to permit Professor Richards, of the University of Pennsylvania, to take from the library three volumes of Bouillon for the purpose of photographing the engravings for his lectures.

The Secretaries were authorized to furnish Mr. Henry Phillips, Jr., one of the Curators, with a letter introductory to foreign correspondents of the Society.

And the meeting was adjourned.

Notes on the Geology of West Virginia. By I. C. White, Professor of Natural History in the University of W. Va.

(Read before the American Philosophical Society, June 17, 1881).

*A Rectification of the Section made by Mr. Howard Grant Jones, M.S., and Published under the Title of "Notes on the Cumberland or Potomac Coal Basin," in Proc. A. P. S., No. 107, pages 111–116.**

The results at which Mr. Jones arrived concerning the duplication of No. XI along the North Potomac river, in his paper read before this Society last year, were so startling, and so much at variance from my own limited knowledge of the geological structure in that region, that I determined to investigate the question anew at the first opportunity. During May of the present year, in company with some members of my class in Geology at the University, we took a five days' excursion through the Piedmont Keyser region, and the present paper is the result.

As will be seen from the sequel, that part of Mr. Jones' section below No. XII is erroneous.

* Read September 17th, 1880.

I find *no duplication of No. XI*, the "2000′ red shale," which Mr. Jones placed in No. XI, being Catskill, separated from the true No. XI by 1150′ of gray Pocono (Vespertine) (X) sandstone; his "440′ Lower Mountain Limestone" is *Lower Helderberg* (No. VI); his "*100′ Pocono sandstone*" *is the White Medina, more than 10,000′ below the true Pocono.*

The line of section extends from Piedmont, Mineral county, West Virginia (and Westernport, Maryland, just opposite), south-eastward along the West Virginia side of the North Potomac, to Keyser (formerly New Creek), and one and a half miles beyond to the summit of Knobby mountain ("Knobbley").

A reference to the accompanying figure will explain the structure of the rocks along the section line which is not far from six and a half miles in length.

As is well known, the Cumberland, or Potomac Coal Basin, lies in a trough of the Allegheny system with Savage mountain bounding its north-western rim, and Dan's mountain* its south-eastern. The North Potomac, after flowing north-eastward down this great syncline for many miles in West Virginia, receives the Savage river at Bloomington, near the Maryland line, whence the combined stream flows eastward across the Basin to Piedmont, two miles below, and then veering to the south-eastward cuts squarely through the Dan's Front Ridge mountain, continuing on across the upturned edges of X, IX, and VIII to Keyser, when trenching through an arch of VII, and the upper portion of VI, across New Creek mountain (ridge), it again flows north-eastward along the north-western slope of Knobby mountain to Cumberland.

From an inspection of the figure, it will be observed that the strata are almost horizontal in the vicinity of Piedmont, and Westernport; that in going south-eastward they soon begin to rise quite rapidly, the lowest beds of No. XII coming up to the south-east at an angle of 12°, three-fourths of a mile below Piedmont. Nos. XI, X, IX, and VIII come up successively with constantly steepening dips until near the middle of VIII, the rocks are vertical; finally near Keyser the Oriskany sandstone, No. VII, comes up with a diminished dip, and arching over the anticlinal axis of New Creek mountain, barely dips down to water level on the North Potomac, making a very shallow and sharp syncline, since it immediately returns with a reverse dip of 65° to the North-west, which carries No. VII, VI, and V into the air over the Walker's ridge anticlinal, one-half mile south-east, to come down again on a south-east dip in the monoclinal range of Knobby mountain, whose crest is formed by the *Oriskany sandstone* (No. VII), and the underlying cherty layers at the top of the Lower Helderberg (No. VI), the varying composition and unequal hardness of which give rise to the peculiar topography that has given name (Knobby) to the range.

A more general discussion of the data in this section is reserved for a

*On the West Virginia side of the Potomac the continuation of this range is called the Allegheny Front Ridge.

future paper. The intervals in the following section were measured directly down to 700′ below top of the Mauch Chunk red shale, with one of Hick's compensated aneroids, the rest of the section being obtained by calculation from the observed dips and measured horizontal distances. The thicknesses thus arrived at are deemed rather under than above the truth, since a small percentage of error must necessarily enter into the construction of every such section.

1.	Massive sandstone, coarse grayish-white, most probably equivalent to one often found in Greene Co., Pa., 100′ below the Waynesburg coal. It caps the summit of Westernport hill		25′ 0″	Upper Coal Measures. 268′
2.	Mostly concealed, but showing some outcrops of flaggy sandstone and shale		130′ 0″	
3.	*Coal blossom*, large, Sewickley?		—	
4.	Concealed		90′ 0″	
5.	Shale, grayish		2′ 0″	
6.	Pittsburgh Coal at Franklin Co.'s new opening, Westernport Hill.			
		Coal, impure	0′ 8″	
		Dark slate	4′ 0″	
		Coal, slaty	1′ 0″	
		Shale, grayish	1′ 0″	
		Roof coal	6′ 8″	
		Coal, main bench, no partings, all good	10′ 0″	
			19′ 8″	
		Slate	0′ 2″	
		Coal, good	0′ 10″	
		Parting	0″-¼″	
		Coal, not mined	2′ 0″	
		Bottom coal	3′ 0″	
7.	Dark slate		0′ 6″	Barrens. 600′
8.	Soft carbonaceous shale		0′ 2″	
9.	Shales, drab		15′ 0″	
10.	Sandstone, flaggy, and shaly		25′ 0″	
11.	Concealed		140′ 0″	
12.	*Coal*, blossom. *Elk Lick?*		—	
13.	Concealed		100′ 0″	
14.	*Coal*, blossom		— —	
15.	Concealed		140′ 0″	
16.	*Coal*		4′ 0″	
17.	Concealed		35′ 0″	
18.	Sandstone, massive, pebbly. Upper Mahoning		30′ 0″	
19.	Concealed, with a *coal* reported 4′ thick just below top of the interval		90′ 0″	
20.	Lower Mahoning S. S., massive, visible		20′ 0″	
21.	Concealed		10′ 0″	
22.	*Coal, Upper Freeport*, Mr. Spangler's opening, Westernport hill.	Coal	2′ 0″	
		Shale, gray	1′ 0″	
		Coal	2′ 0″	
			5′ 0″	
23.	Concealed		10′ 0″	

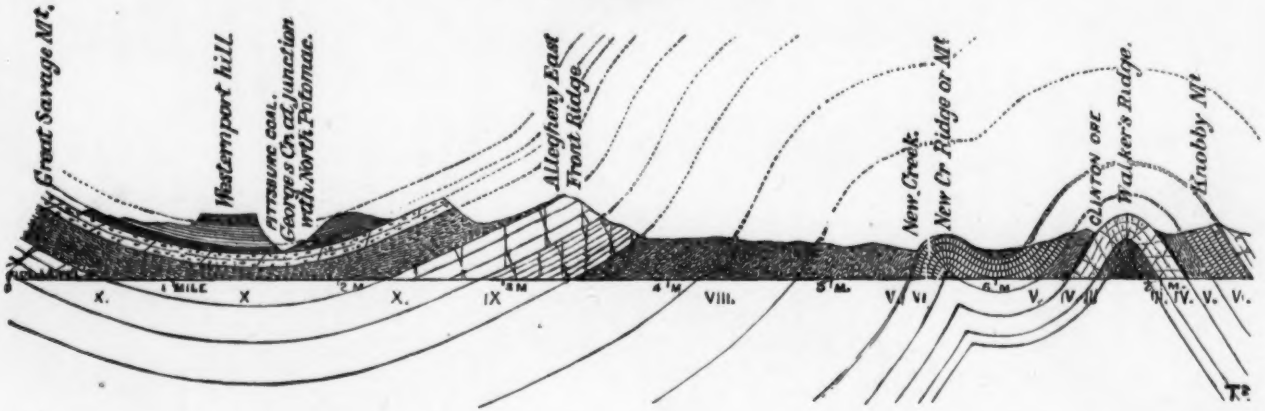
24.	Shale, bluish	10′ 0″		Lower Productive
25.	*Coal*	2′ 6″		
26.	Fireclay	2′ 0″		
27.	Concealed	10′ 0″		
28.	Sandstone, very hard	2′ 0″		
29.	" shaly	5′ 0″		
30.	Shales, sandstone and concealed	55′ 0″		
31.	Dark bituminous shales	5′ 0″		
32.	*Coal*, visible	2′ 0″		
33.	Dark shales and concealed	10′ 0″		
34.	Very massive sandstone, Lower Freeport	50′ 0″	268′	
35.	Shales, drab	0′–5′ 0″		
36.	*Coal* {Middle Kittanning / Darlington} Mr. Spangler's opening in Westernport hill. — *Coal*, slaty 1′ 0″; Bony coal 0′ 8″; Coal, pyritous 1′ 4″; Slate, hard 0′ ½″; Coal, best 2′ 6″	5′ 6½″		Coal Measures.
37.	Fireclay, very sandy	3′ 0″		
38.	Shales with nodular *iron ore*	2′ 0″		
39.	Fireclay, impure	4′ 0″		
40.	Flaggy sandstone	20′ 0″		
41.	Concealed	25′ 0″		
42.	Fireclay, very sandy and impure	10′ 0″		
43.	Flaggy sandstone	10′ 0″		
44.	Sandy shales	15′ 0″		
45.	Massive sandstone {Piedmont / Homewood}	20′ 0″		No. XII, or Conglomerate
46.	*Coal*	2′ 0″		
47.	Dark shales, containing many fossil plants, *Pecopteris dentata, P. polymorpha, Neuropteris flexuosa, N. acutifolia, Odontopteris* sp.? and many other common *Coal measure* forms; also many nodules of "Kidney" *iron ore*, all seen in cutting at Davis's bridge (Saw mill road) opposite Piedmont	45′		
48.	Sandstone, hard, somewhat current bedded, inclined to be flaggy, weathering in holes, seen in cliff to level of North Potomac, at Piedmont, just above the C. & P. R. R. bridge	40′ 0″		
49.	Dark shales (coaly) and concealed	30′ 0″		
50.	Sandstone, flaggy	10′ 0″		
51.	Shale, dark olive	2′ 0″		
52.	*Coal*	1′ 6″		
53.	Fireclay, dark, sandy	12′ 0″		
54.	Sandstone, flaggy, with *coal streaks*	10′ 0″		
55.	*Coal*	1′ 6″		
56.	Shale with nodular *iron ore*	2′ 0″	451′	
57.	Shales and flaggy sandstone	40′ 0″		

58.	Massive, very hard, grayish-white fine grained sandstone, with some small pebbles, exhibiting in its lower portion between the layers, at intervals of 2′ to 3′ a kind of imperfect crystallization, by which a vertical section through the layers much resembles along the bedding planes the large interlocking teeth of an animal. This peculiar structure was observed at localities 2 ms. distant, and seems to be characteristic of this stratum in the Piedmont region. Seen forming a long line of cliffs on the Maryland side of the Potomac, 1 mile below Piedmont, and also capping the summit of the Front Ridge Allegheny on the W. Va. side, 2 ms. below Piedmont	45′ 0″	Measures.
59.	*Coal shale*	5′ 0″	
60.	Concealed with some shale and flaggy S. S. visible	145′ 0″	
61.	Sandstone, massive	10′ 0″	
62.	Bituminous shale	10′ 0″	
63.	Sandstone, flaggy	10′ 0″	
64.	Sandstone, massive, whitish (base of XII)	20′ 0″	
65.	*Coal*, seen at roadside along the Maryland shore of North Potomac, 1 m. below Piedmont	1′ 0″	Umbral (No. XI), 852′ or Mauch Chunk Shales.
66.	Sandstone, drab	4′ 0″	
67.	Fireclay and shale	3′ 0″	
68.	Sandy shale	4′ 0″	
69.	Shales, brown, containing *iron ore*	10′ 0″	
70.	*Red shale*	10′ 0″	
71.	Sandstone, flaggy, greenish-gray, with much shale	40′ 0″	
72.	Concealed	40′ 0″	
73.	Sandstone, somewhat massive, greenish-gray	20′ 0″	
74.	Concealed, but showing occasional appearances of *red shale*, and very probably largely composed of that material	375′ 0″	
75.	Sandstone, somewhat massive, but often inclined to be flaggy, greenish-gray; seen in cliffs along the B. & O. R. R. cuts, near the 205th mile post from Baltimore, below Piedmont	130′ 0″	
76.	*Red shales*	35′ 0″	
77.	Shales, greenish, sandy	20′ 0″	
78.	*Red shale* to level of B. & O. R. R. track at little run 76 rods east from the 205th m. p. from Baltimore	10′ 0″	
79.	Concealed	150′ 0″	
80.	Limestone, gray, fossiliferous, containing *Spirifer keokuk, Athyris sub-quadrata, Productus cora, Hemipronites crassus*, and many *Crinoidal* fragments	10′ 0″	Mountain Lime
81.	Concealed, but probably containing several layers of limestone	90′ 0″	
82.	Limestone, gray, massive	5′ 0″	

Proc. Amer. Philos. Soc., Vol. XIX. No. 109.

Section from the eastern escarpment of Savage Mt through Westernport (Md.) hill crossing to the W. Va. side of the North Potomac at the mouth of Georges Creek. and continuing along the same S.25°E. to the summit of Knobby Mt

Scale 6000' to an Inch.



Second Geological Survey of Pennsylvania.

Constructed May 1881 by Prof. I. C. White.

83. *Red shales* and concealed..... 140′ 0″ } 340′
84. Sandstone, coarse, brownish, visible ..... 5′ 0″
85. Concealed ..... 50′ 0″
86. Limestone, grayish-white, no fossils seen..... 10′ 0″
87. *Silicious Limestone* (of Stevenson in Fayette and Westmoreland, Pa.), exhibiting a wavy or current bedded structure and giving forth a metallic resonance when struck with hammer..... 30′ 0″ } stone (No. XI.)

88. *Vespertine, Pocono,* or *No. X,* consisting of gray, current bedded, mostly flaggy sandstones, no conglomerates seen, nor red shales; rising at an angle of 18°—20° towards the S. E. and extending along the B. & O. R. R. for 58 chains, the lowest layers rising above R. R. level 33 chains east from the 204th Baltimore m. p. Thickness, about.....1150′

89. *Catskill,* or *No. IX,* consisting of dark red shales alternating with red, and greenish-gray sandstones, containing *fish remains,* but no molluscan seen; rising towards the S. E. at an angle of 25° at top and 35° where the bottom layers come up 7 chains west of the 203d m. p. thus making a vertical thickness of, say.....1300′

90. *Chemung,* consisting of alternate layers of thin, olive sandstones, and shales, very fossiliferous, and perfectly exposed along the B. & O. R. R. in vicinity of 203d m. p.; coming up towards the S. E. at an angle of 35°, and at the end of 10½ chains the dip is increased to 45°, thus giving an approximate thickness of Chemung down to this point of about.....400′ } Rocks certainly Chemung.
91. *Conglomerate,* composed of very thin, flat, rounded quartz pebbles, in a matrix of coarse rotten sand with numerous fossil shells imbedded, very forcibly reminding one of the Venango Lower (3d) Oil Sand; thickness..... 2′ } 602′
92. Chemung flaggy sandstones and shales continue rising at an angle of 45° for 16 rods further towards the S. E. all perfectly exposed, and very fossiliferous; thickness about.....200′

93. Concealed, 13½ chains, at the end of which the strata are rising at an angle of 62° towards the S. E. thus making the intervening rock thickness about..... 700′

94. *Conglomerate,* a gray, hard sandstone, containing numerous layers filled with flattish, white quartz pebbles..... 40′

95. As we go S. E. from this point toward Keyser, the rocks rapidly increase their dip to the N. W. and at ½ mile from the outcrop of No. 94, are vertical; continuing thus or even slightly bent over beyond the perpendicular to the end of 100 chains (1¼ ms) from No. 94. Exposures are rare in this interval, as there are

seldom more than 5′—10′ exposed at any one locality, and these are in every case olive, and drab colored shales. The topography also shows that no hard nor massive rocks occur in this interval, since on entering it the mountain immediately breaks down to the S. E., giving a broad valley along the Potomac, bordered by gently sloping hillocks. The interval includes all the rest of No. VIII, whatever there may be of *Portage*, *Hamilton* and *Corniferous*, and its thickness cannot be less than.....6000′

96. *Oriskany Sandstone* (No. VII), rises above the North Potomac nearly opposite the dèpot at Keyser, and arching up over New Creek ridge (mountain) forms the bold cliff at Queen's point, opposite Keyser, 400′ almost vertically above the river; a very coarse, brownish sandstone, filled with its characteristic fossils, *Spirifer arenosus*, *Rensaelaeria ovoides* and *Platyceras ventricosum*; it comes down to the river at the R.R. cut a short distance east from Keyser, with a strong south-east dip, but immediately returning it comes up again with a strong N. W. dip (65°), and arching up passes in the air over the next anticline to come down again along the (monoclinal) crest of Knobby mountain ("Knobbley"). Thickness..... 75′

97. *Lower Helderburg* (No. VI); at top a gray silicious limestone, with several layers of flint 6″—10″ thick, interstratified for about 150′, then follow blue and gray layers of pure limestone richly *fossiliferous*, *Strophomena radiata*, *S. rugosa*, *Pentamerus pseudo-galeatus*, *Rhynchonella ventricosa*, *Spirifer macropleurus*, *Atrypa reticularis*, *Tentaculitus ornatus*, *Leperditia alta*, besides numerous species of *Favosites*, *Zaphrentis*, *Stromatopora*, and *Chætetes*, being very abundant. Very fine *Trilobites* are also reported from some of the quarries, which from their (reported) size must be species of *Asaphus*. This is the limestone which was identified in H. G. Jones's section as the *Lower Mountain Limestone* of XI, and 440′ thick. My measurements make it much thicker, however; it is finely exposed along Limestone run one-half mile S. E. from Keyser; it makes the N. W. slope of Knobby mountain all the way between Keyser and Cumberland, the upper silicious layers often forming the irregular crest of the same; its uppermost 300′ are also exposed under the great arch of Oriskany Sandstone at Queen's point opposite Keyser, where the North Potomac cuts through New Creek mountain. The fossils given were all seen in the upper portion of the formation. No attempt was made to subdivide the series, which consists of limestone throughout, the measurement of which south-eastward along Limestone run gave the horizontal distance through it 18 chains, with a N. W. dip of 63°, which would give a thickness of.....1050′

98. A succession of shales, marls and thin shaly limestones, with occasional brown flaggy sandstones; near the centre of which occur very strong *salt springs* from which considerable salt was formerly manufactured, the whole representing the *Salina group* of New York. Thickness about..... 350′

99. (*a*) Hard gray flaggy sandstone, 20′, then follows
(*b*) a succession of brownish sandy shales with a few thin layers of impure limestone near the centre, and two layers of *iron ore*, the one 6″ the other 12″ thick, and separated by 10′ of shales, 50′ below the centre; thickness about 300′. Then comes
(*c*) the main mass of the *Clinton fossil iron ore* 20′ thick, quite rich in iron, but entirely too siliceous; once shipped from the land of Mr. N. Alcaire on Limestone run by Uniontown, Pa., parties to Lemont Furnace and one or two in Pittsburgh, but after a thorough trial condemned by them all as too siliceous.
(*d*) Shales, 40′ thick.
This whole group (*a*, *b*, *c*, *d*), and probably a portion of the overlying 350′ in No. 98, representing whatever there may be of Niagara (if any) and all of the *Clinton* (No. V); entire thickness (*a*, *b*, *c*, *d*)..... 380′

100. *Medina Sandstone* (No. IV in part), seen forming the lowest rocks in the ridge (anticlinal) half way between New Creek mountain and Knobby range, the upper portion reddish brown to gray iron-stained sandstone, containing *Anthrophycus harlani* in great numbers, thickness 150′; lower portion an almost snow-white, very hard, fine grained sandstone, some portions slightly streaked with iron, thickness 125′; finely exposed on Limestone run, one mile above its mouth where that stream cuts through the Walker's Ridge axis. This is the stratum which Mr. H. G. Jones identified as the *Pocono*, or white sandstone of X, the 100′ sandstone with which his section ends (see Proc. A. P. S. Vol. XIX, No. 107, page 116). (On the B. & O. R. R., one mile west from Brady's Mills, 15 miles east from Keyser this white sandstone is seen in a R.R. cut 100′ thick, and below it 500′ of drab, brown, and bluish shales ending in flaggy sandstones at base.) Entire thickness of Medina at Keyser to base of white sandstone..... 275′

SUMMARY.

Carboniferous.

Upper Coal measures (XV).....	268′	
Barrens (XIV)	600′	
Lower Coal measures (XIII).....	268′	
Conglomerate measures (XII).....	451′	3929′
Mauch Chunk shale 852′ } Mountain Limestone 340′ } (XI).....	1192′	
Pocono (Vespertine) (X).....	1150′	

Devonian.

Catskill (IX)		1300′	
Chemung, Portage, Hamilton, Upper Helderburg (Corniferous)	(VIII)	7342′	8717′
Oriskany Sandstone (VII)		75′	

Upper Silurian.

Lower Helderburg Limestone (VI)		1050′	
Salina, Niagara?, Clinton	(V)	730′	2555′
Medina Sandstone 275′	(IV)	775′	
Medina shales * 500′	(in part)		
Total height of section			15,201′

Photodynamic Notes, III. By Pliny Earle Chase, LL.D., Professor of Philosophy in Haverford College.

(*Read before the American Philosophical Society, June 17, 1881.*)

46. *Stellar Relations of the Corona Line and of Mass.*

The laws of harmonic æthereal oscillation, which fix planetary nodes within the solar system in accordance with spectral lines (Note 37), should also be manifested between stellar systems. Such a manifestation is found in the proportion

$$1^2 : (316.53+1)^2 :: 460 : 46{,}379{,}800 \quad \ldots\ldots (1)$$

In this proportion, the mass at the centre of condensation (Earth) is represented by 1; the mass at the centre of nebulosity (Jupiter) by 316.53; the distance of *a Centauri* by 46379800; the distance of Earth's nascent locus (Note 45) by 460, or the cosmical equivalent of the corona line. The square of the mass varies as reciprocal *vis viva*, or orbital *vis viva* at uniform distance, and also as distance of orbital projection at uniform distance against uniform resistance.

The abscissas of the stellar-solar paraboloid may therefore be computed by means of Sun's semi-diameter, Laplace's limit, and the corona line, as follows:

$$v_\lambda = 214.45\, r_\circ \div 497{,}827 = .4307721\, r_\circ \quad \ldots\ldots (2)$$

$$v_\circ = 2\pi\, r_\circ \times 214.45^{\frac{3}{2}} \div 31558149 = .0006252556\, r_\circ \quad \ldots\ldots (3)$$

$$g_\circ = v_\circ^2 \div r_\circ = .0000003909446 r_\circ \quad \ldots\ldots (4)$$

$$t_r = 2v_\lambda \div g_\circ = 2203750 \text{ sec} \quad \ldots\ldots (5)$$

*Seen near Brady's Mills, 15 miles east from Keyser.

$$L = 214.45 r_0 \left(\frac{t_r}{1 \text{ year}}\right)^{\frac{2}{3}} = 36.3658 r_0 \ldots\ldots\ldots\ldots\ldots\ldots (6)$$

$$M = \left(\frac{v_\lambda}{v_0}\right)^2 r_0 = 474657.14 r_0 \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (7)$$

$\log. \xi = \log. \frac{1}{R} = -.7781513$

$\log. \xi + \log. 19\eta + \log. 361\zeta = \log. (\frac{1}{3}L) = 1.2085109 \ldots\ldots\ldots$

$\log. \xi + \log. 39\eta + \log. 1521\zeta = \log. [(317.53)^2 \times 460.002] = 7.6663302.$

$\therefore \quad \log. \zeta = .0055982.$

$\log. \eta = -.0018046316.$

The following table gives the logarithms, both of the centripetal and the centrifugal abscissas, as calculated by the formula :

$$\log. A_n = \log. \xi \pm n \log. \eta + n^2 \log. \zeta.$$

n	Centripetal, $(\log. \xi + n \log. \eta + n^2 \log. \zeta)$.	Centrifugal, $(\log. \xi - n \log. \eta + n^2 \log. \zeta)$
0	—.7781513	—.7781513
1	—.7743577	—.7707485
2	—.7593678	—.7521492
3	—.7331814	—.7223536
4	—.6957986	—.6813616
5	—.6472195	—.6291731
6	—.5874439	—.5657883
7	—.5164719	—.4912071
8	—.4343036	—.4054294
9	—.3409388	—.3084554
10	—.2363776	—.2002850
11	—.1206200	—.0809182
12	.0063339	.0496451
13	.1444843	.1914047
14	.2938311	.3443607
15	.4543742	.5085132
16	.6261138	.6838620
17	.8090498	.8704072
18	1.0031821	1.0681489
19	1.2085109	1.2770869
20	1.4250361	1.4972213
21	1.6527576	1.7285522
22	1.8916756	1.9710794
23	2.1417900	2.2248030
24	2.4031007	2.4897231
25	2.6756079	2.7658395
26	2.9593115	3.0531523
27	3.2542114	3.3516616
28	3.5603078	3.6613672
29	3.8776006	3.9822692

	Centripetal.	Centrifugal.
30	4.2060898	4.3143676
31	4.5457753	4.6576625
32	4.8966573	5.0121537
33	5.2587357	5.3778413
34	5.6320104	5.7547254
35	6.0164816	6.1428058
36	6.4121492	6.5420826
37	6.8190131	6.9525559
38	7.2370735	7.3742255
39	7.6663302	7.8070915

In each set, the nine abscissas from 12 to 20 inclusive, and the nine from 30 to 38 inclusive, have no obvious* significance, except as indicating a symmetrical division of the abscissas, into three groups of 3^2 each, between the star and the Sun's surface. The nine from 21 to 29 inclusive indicate different planetary influences in the two sets, which seem to be worthy of further study. If we take the anti-logarithms and divide by 214.54, in order to get the abscissas in terms of Earth's semi-axis major, we find the following accordances :

n	Centripetal.	Planetary loci.		Centrifugal.	Planetary loci.	
21	.210	$\frac{1}{2}$	Mercury, .199	.250	Mercury s. p.,	.297
22	.363	$\frac{1}{2}$	Venus, .362	.436	" m. a.,	.456
23	.646	$\frac{2}{3}$	Earth m. p., .644	.782	Venus s. a.,	.774
24	1.180	$\frac{3}{4}$	Mars, 1.142	1.440	Mars m. p.,	1.403
25	2.209	$\frac{4}{5}$	Asteroid 55, 2.208	2.720	Asteroid 45,	2.720
26	4.246	$\frac{5}{6}$	Jupiter, 4.336	5.270	Jupiter,	5.203
27	8.374	$\frac{6}{7}$	Saturn, 8.176	10.479	Saturn s. a.,	10.343
28	16.943	$\frac{7}{8}$	Uranus, 16.786	21.382	Uranus s. a.,	20.679
29	35.178	$\frac{7}{8}$	Neptune, 35.040	44.765	$\frac{8}{9}$ Neptune m. p.,	44.598

The foregoing table furnishes the following indications :

1. That there are harmonic influences upon relative mass and position extending from the stars to the Sun, of a similar character to those which are manifested within the solar system.

2. That these are the only known and measurable evidences, which have yet been discovered, of inter-stellar action.

3. That the influences are of such a character as are required by the resistance of nodes of great comparative inertia in a highly elastic vibrating medium.

4. That there is, therefore, some inter-stellar medium, to which the laws of elastic action and reaction are applicable.

* We find, however, upon examination, that log. A_{38}, 7.2370735)) is equal to log. L + log M, or log. LM, (1.5606934 + 5.6763800). This gives four elements for determining the paraboloid, where only three are required. Any three of the elements furnish data for determining the masses of Sun, Jupiter and Earth; Sun's volume and density; Laplace's limit; solar modulus of light; corona line; stellar distance and the rupturing planetary loci.

5. That the inter-stellar radial influences are so modified, by mutual action and re-action, as to become paraboloidal.

6. That the centripetal influences tend to produce and maintain nebular condensation, planetary segregation and orbital revolution.*

7. That the centrifugal influences tend to produce and maintain mean or apsidal positions for the condensed planets.

8. That the harmonic waves are propagated with the velocity of light.

9. That the controlling mass of the whole solar system (Sun), as well as the subordinately controlling masses of the extra-asteroidal and intra-asteroidal belts (Jupiter, Earth), are harmonically dependent upon the oscillations of the inter-stellar medium.

10. That the corona-, hydrogen-, and basic-lines serve to link cosmical with chemical, molecular, and other physical phenomena.

11. That the outermost known planet (Neptune) gives evidences of nebular influence, in its centrifugal as well as in its centripetal abscissa, the centripetal coefficient being the reciprocal of Saturn's, and the centrifugal coefficient being the reciprocal of Earth's centripetal. The centrifugal abscissa represents the locus of a nebular surface which would yield planetary aggregation in Neptune's orbit, through subsidence-collision.

12. That the centre of condensation (Earth) has no special centrifugal abscissa.

13. That the centrifugal abscissas for Venus and Mars point to early apsidal stages of central condensation.

14. That Earth's centripetal abscissa represents the locus of belt-formation in a nebula extending to Earth's mean rupturing locus (mean perihelion).

15. That the elements of the controlling paraboloid are all maxima, r_0, (Sun's semi-diameter), being the locus of greatest gravitating energy; L, (Laplace's limit), the limiting locus of greatest possible atmosphere; Jupiter and Earth, the greatest and controlling masses of their respective belts.

16. That the velocity of light and Sun's mass, upon which r_0 and L depend, are also maxima, and all physical phenomena within the system should be in harmonic dependence upon their mutual actions and reactions.

47. *Physical Units of Nature.*

In the Philosophical Magazine for May, 1881, Dr. Stoney republishes a paper on physical units, which he read before the British Association in 1874, giving approximate values for L_1, T_1, M_1. More than five years before his original paper was read, I had communicated to the American Philosophical Society† the equation, $u = g_1 t_1$, in which $u =$ velocity of light, which Stoney represents by $V_1 = 3$ VIII metres per second; $g_1 =$ acceleration of gravity at Sun's equatorial surface; $t_1 = \frac{1}{2}$ time of solar rotation.

*See ☞, *ante*, pp. 205-6.
†Proc. A. P. S., xi, 106-7.

This equation furnished the data for computing a less arbitrary series of natural units, L_o, T_o, M_o. The British Nautical Almanac gives an estimate of Sun's apparent semi-diameter, (r_o), which makes Earth's semi-axis major equivalent to 214.45 r_o. Hence we find (see foregoing note):

$V_o = V_1 = v_\lambda = .4307721\ r_o = 3$ VIII metres.
$v_o = .0006252556\ r_o = 435443$ metres.
$G_o = .0000003909446\ r_o = 272.26$ metres.

$$L_o = \left(\frac{V_o}{v_o}\right)^2 r_o = 474657.14\ r_o = 33 \text{ XIII metres} = \text{solar modulus of light.}$$

$$T_o = \frac{V_o}{G_o} = 1101875 \text{ sec.}$$

$M_o \propto gr^2 = 331700 \oplus = 2$ XXXIII grammes.

Among the apparent advantages of these units over those of Dr. Stoney, are the following:

1. L_o is the height of a homogeneous æthereal solar envelope, which would propagate waves with the velocity of light.

2. T_o is the time in which the sum of the solar centripetal accelerations of maximum gravitation is equivalent to the sum of the solar reactions against the centre of gravity of all other cosmical bodies, in the alternate projection from and return towards the disturbing centre of gravity.

3. M_o is the controlling mass of the system, and, consequently, of all the physical phenomena which occur in any part of it.

4. L_o, T_o, M_o can be estimated more easily and more accurately than L_1, T_1, M_1.

5. G_o is the greatest possible gravitating acceleration within our system.

6. V_o is the greatest known velocity of wave-propagation. It is true that Wheatstone's unconfirmed experiments, as well as my own ratio of *vis viva* of excursion to *vis viva* of propagation (9 : 5), indicate greater possible velocities. But Wheatstone did not eliminate the influence of induction, and Maxwell's application of my ratio was confined to the excursion of particles through very narrow limits.

7. All of those maxima are eminently *natural* maxima, and, therefore, suitable for natural standards.

The following equations show the mutual relations of the two sets of units:

$$L_o \div L_1 = 33 \text{ L.}$$
$$T_o \div T_1 = 33 \text{ L.}$$
$$M_o \div M_1 = 2 \text{ XL.}$$

48. *Rotating Vis Viva.*

The photodynamic ratio of the velocity of light to the equatorial velocity of stellar rotation is expressed, as I have shown (Note 34), by the proportion

Stellar modulus of light : stellar semi-circumference : : v_λ : v_r.

The centre of gravity of the universe must be stable, so far as any modi-

fying action of its constituent bodies is concerned. The particles of a star or nebula, exposed to æthereal oscillations, are solicited simultaneously towards the local and towards the universal centre of gravity. The accelerations, relatively to the stellar or nebular centre, on the side towards the universal centre, and the retardations on the opposite side, necessarily produce rotation. The duration of the rotation must be such as to maintain cyclical equilibrium among the three activities of general luminous undulation, general gravitation and local gravitation.

Equality of action and reaction should lead to harmonies of *vis viva* and of mass, which may become especially prominent when there are two largely preponderating bodies in a system, as in the case of Sun and Jupiter. Their mutual actions and reactions, being exerted through a common radius, are proportioned to their masses. The mean *vis viva* of rotation being represented by a virtual projection of mass through $.4\,r$, if we consider the modulus of light as the virtual projection due to Sun's mass during the cyclical disturbances of equilibrium, we may suppose

Sun's mass : Jupiter's mass : : Modulus : .4 Jupiter's semi-axis major.
1047.879 : 1 : : 474657.14 : 453

Jupiter's semi-axis major is $5.2028 \times 214.45 = 1115.74$; .4 of $1115.74 = 446.3$.

The theoretical projection is, therefore, 1.0149525 times the mean-projection, and there is an exact accordance, twice during each revolution of Jupiter around the Sun. For, according to Stockwell,* the secular minimum value of Jupiter's eccentricity is equal to .0254928. Neptune's maximum eccentricity, according to the same authority, is .0145066, and $\frac{1}{7}$ of the mean eccentricity of Uranus is .0149538. These accordances seem significant, in view of Jupiter's central nebular position between Uranus and Neptune, at their opposition.

49. *Further Stellar Relations of Mass.*

The paraboloidal formula, $x_n = \xi \eta_1^n \zeta^{n^2}$, may be expressed under the form $x_n = \xi\,(\eta\,\zeta)^n\,\zeta^n$, the successive terms being found by the product of corresponding terms of two geometrical series. They may, therefore, be taken to represent the mutual actions and reactions of two co-ordinate masses, like Sun and Jupiter. The geometric variations of density, which accord with arithmetical variations of distance, suggest the proportion, (Note 46):

Sun's mass : Jupiter's mass : : x_{39} : 39 × Jupiter's semi-axis major.
1047.879 : 1 : : 46379946† : 44260.8

This gives, for Jupiter's theoretical semi-axis major, $44260.8 \div 39 = 1134.9$, which is 1.017165 times the estimate of the British Nautical Almanac (Note 48). This is less than the secular minimum aphelion of Jupiter, so that the locus is traversed twice during each revolution of Jupiter about the Sun.

* Smithsonian Contributions, 232, p. 38.

† The *logarithm* of x_{39} being 7.6663302, the abscissa itself is 46379946 r_0.

If we make the greatest possible allowance for uncertainties of data, the relations of inter-planetary and inter-stellar distances to the three important masses, which are shown by the present note and the three foregoing notes, are close enough to be very curious, even if we could think them merely accidental. Inasmuch as they have been discovered by a simple consideration of the consequences which ought to follow, through the known laws of elasticity, from the interruption of luminous vibrations and the formation of nodes by cosmical inertia, they are more than curious, for they are indicative of the unity of energy which has long been thought to control all physical manifestations.

50. *Harmonic Masses.*

Twice modulus is the radius of rectilinear oscillation, which would be synchronous with orbital oscillation about a major axis equivalent to that of the homogeneous æthereal atmosphere. The dependence of modulus upon solar mass and radius makes it probable that there may be a harmonic dependence, of a like character, among the principal planetary masses. We find, indeed, that the four extra-asteroidal planets have harmonic masses, inasmuch as they may all closely be represented by the formula $\frac{\text{Sun}}{\text{Planet}} = \frac{2 \times \text{Modulus}}{n\, r_0}$, in which n is integral, so that the second member of the equation gives four terms of a harmonic progression.

$n\, r_0$	$2M \div n\, r_0$	Computed Values.	Authority.
$906\, r_0$	1047.81	1047.88 = Sun ÷ Jupiter.	Bessel.
$271\, r_0$	3503.	3501.6 = Sun ÷ Saturn.	"
$42\, r_0$	22603.	22600. = Sun ÷ Uranus.	Newcomb.
$49\, r_0$	19374.	19380. = Sun ÷ Neptune.	"

That these approximations are not accidental, may be shown by comparing the probable with the actual deviations from exact accordance.

Probable.	Actual.	P ÷ A.
$\frac{1}{4}$ of $\frac{1}{9\,0\,0} = .00027$	$7 \div 104781 = .000067$	4
$\frac{1}{4}$ of $\frac{1}{2\,7\,1} = .00092$	$14 \div 35030 = .000399$	2.3
$\frac{1}{4}$ of $\frac{1}{4\,2} = .00595$	$3 \div 22603 = .000133$	46
$\frac{1}{4}$ of $\frac{1}{4\,9} = .00510$	$6 \div 19380 = .000309$	17

The deviations are so far within the limits of probable errors of mass that the accordance may, perhaps, be exact. But absolute exactness, in the satisfaction of any mechanical tendencies is not to be expected. There are so many and so various modifying influences, in all cases, that any result which is in complete accordance with theory should be regarded as more suspicious than one which suggests slight perturbations from some unknown cause.

51. *Subordinate Masses.*

If "the exception proves the rule," we may find that the perturbations, which were spoken of in the foregoing note, may introduce apparent exceptions, in subordinate masses, which are really confirmatory of the har-

monic tendencies in larger masses. Taking the nearest integral values of n for each of the intra-asteroidal planets, we may construct the following comparative table:

$n\,r_0$.	$2\,M \div n\,r_0$.	Computed Values.	Authority.
1	959314	3093500 = Sun ÷ Mars.	Hall.
3	319771	331700 = Sun ÷ Earth.	Chase.
2	479657	427240 = Sun ÷ Venus.	Hill.
1	959314	4865751 = Sun ÷ Mercury.	Encke.

The actual values of nr_0, which would give the computed values of mass, are .307, 2.862, 2.222, .204. There is an approximation to the integral values of n, in the cases of Earth and Venus, that of Earth having the same probability as that of Saturn, 2.3. The probability for Venus is only $\frac{1}{2}$ as great, or 1.15. The masses of Mercury and Mars are evidently controlled by some other law, which overrides that of the repetition of solar radial nodes.

52. *Reciprocal Coefficients.*

I have pointed out* the reciprocity between the coefficients of the stellar-solar abscissas which indicate rupturing loci for Saturn and Neptune. This reciprocity is interesting, not only for indicating the inverse rotation of two portions of a primitive nebula, but also for introducing the harmonic ratio of mass, into the retrograde portion, which is shown in Note 50. We accordingly have the two following proportions:

$$x_7 : \rho_7 :: m_8 : m_9 :: 6 : 7.$$
$$x_9 : \rho_9 :: m_9 : m_8 :: 7 : 6.$$

In these proportions, x represents the stellar-solar abscissa, or rupturing locus; ρ, semi-axis major; m, mass; subscript $_{7,\ 8,\ 9}$, Saturn, Uranus, Neptune.

53. *Total Planetary Mass.*

Notes 46, 48, 49 and 52 indicate the probability of some photodynamic influence in determining the primitive ratio of solar (m_0) to planetary mass (m_n). On examination we find

$\frac{1}{2}$ modulus	: Sun's semi-diameter	: :	m_0^2	$: m_n^2$.
553767	: 1	: :	744.155^2	$: 1^2$.

The following table gives the computed masses of the several planets, Sun's mass being represented by 10,000,000,000.

Mercury,	2,055	Encke.
Venus,	23,406	Hill.
Earth,	30,148	Chase.
Mars,	3,233	Hall.
Jupiter,	9,543,087	Bessel.
Saturn,	2,855,837	Bessel.
Uranus,	442,478	Newcomb.
Neptune,	515,996	Newcomb.
Sum,	13,416,240 = $m_0 \div 745.365$.	

**Ante*, p. 209.

This value differs by less than $\frac{1}{6}$ of one per cent. from the above theoretical value. If the sum of the asteroidal and cometary masses is about $\frac{2}{3}$ as great as Earth's mass, the accordance is exact. The additional evidence which it furnishes, both of early photodynamic rupturing and reciprocally rotating influences, ($\frac{7}{4}$, $\frac{4}{7}$), may prove to be as important as it is interesting. The total planetary mass is very nearly 2×7 times the retrogradely rotating mass of Uranus and Neptune.

54. *Atomic Weights.*

The close approximation to integral mass-divisors (Notes 50, 51), in all the known primary planets except Mercury and Mars, is like the atomic approximations to exact multiples of the hydrogen unit. This fact, together with the many evidences of tendencies to harmonic wave-lengths among spectral lines, suggests the probability of harmonic influences upon atomic weight, as well as upon atomic velocity.

There is still so much uncertainty in regard to many of the atomic weights, that it is impossible to determine, with exactness, the various subdivisions of which any given element may be susceptible. It is evident, however, that certain factors enter more frequently into the atomic ratios than could be looked for from the mere laws of probability, and it does not seem unreasonable to hope for future light upon the nature of chemical combination, from the study of mathematical combinations.

The factors which seem worthy of special attention are, 2, 2^2, 2^3, 2^4, 3^2, 5^2, 7, 13. The combination of the powers of 2 with prime numbers is shown in the following table:

	1	3	5	7	11	13
2	—	—	—	N	—	—
4	—	C	—	Si	Sc	Cr
8	—	Mg	Ca	Fe	Y	Ru, Rh
16	O	Ti	Br	Cd	—	—
32	S	Mo	—	—	—	—

The following groups are also suggestive:

4×3	C	4×22	Y	7×1	Li	7×26	Ta
4×4	O	4×24	Mo	7×2	N	7×30	Bi
4×6	Mg	4×26	Ru, Rh	7×4	Si		
4×7	Si	4×27	Ag	7×5	Cl	13×3	K
4×8	S	4×28	Cd	7×8	Fe	13×4	Cr
4×10	Ca	4×35	Ce	7×9	Cu	13×5	Zn
4×11	Sc	4×45	La	7×10	Ga	13×6	Se
4×12	Ti	4×46	W	7×16	Cd	13×8	Ru, Rh
4×13	Cr	4×50	Hg	7×18	Te	13×14	Ta
4×14	Fe	4×51	Tl	7×19	Cs	13×15	Os
4×17	Ga	4×52	Bi	7×20	Ce	13×16	Bi
4×20	Br	4×60	U				

Bismuth, on account of the uncertainty of its equivalent, appears in each

group. If 208 is its true value, it should be excluded from the first two groups. All these arrangements are, for the present, only tentative, but I think that an increase in accuracy of determination will be more likely to increase than to diminish the number of indications of this kind.

My anticipation of a "ponderable disturbance of equilibrium, which must give rise to æthereal oscillations in every chemical action," was published in 1864*. The confirmations of that anticipation, by Cooke, Mendelejeff, Meyer and others, lead me to hope that a careful consideration of the common factors in different supposed elements will help towards further analysis and, perhaps, towards the final discovery of the laws by which all chemical substances are developed from a single primitive form of matter.

55. *A Natural Thermal Unit.*

Any expression for the mechanical equivalent of heat which introduces the degrees of a thermometer-scale, must have an arbitrary character which may interfere with the ready conversion of thermal into other dynamic measurements. Moreover, it may well be questioned whether the mass-factor should be chosen, rather than the velocity-factor of *vis viva*, as a unit of comparison. If we consider force as a representative of matter in motion, different kinds of force would seem to be fitly characterized by differences of velocity rather than by differences of mass.

There is an obvious propriety in taking water as a representative medium, but there is no more need of considering a pound, or a kilogram, or any other definite quantity, in ordinary thermodynamic investigations, than there is in chemical researches. The three changes of state through which water passes, represent different well-defined amounts of work. The changes from gas to vapor and from liquid to solid do not involve any essential change of form, but the change from vapor to liquid converts an indefinitely expansible and compressible substance into one which is but slightly expansible and almost incompressible. It thus furnishes a natural thermal unit (v_k), which is a bond between tendencies to aggregation and to dissociation and a convenient standard for comparison between the equal actions and reactions of various forms of energy.

An atom or quantity x of water, in passing from the fusing to the boiling temperature, absorbs an energy sufficient to lift itself 772×180 feet, or 423.54×100 metres. This represents a wave- or projectile-velocity $v_k = \sqrt{2\,gh} = 2986.3$ feet $= .56558$ miles $= .9102$ kilometres per second.

56. *Weighing the Sun by the Thermometer.*

In two wave-systems, which are due, either directly or indirectly, to synchronous actions and reactions between two different masses, the wave-velocities are proportioned to the producing masses; for $v_k \propto gt \propto \frac{\mu\, t}{r^2} \propto \mu$. We have already found (Note 47) that the wave-velocity of solar

*Proc. Amer. Phil. Soc., ix, 439.

reaction against æthereal action ($G_o T_o$) is the velocity of light (v_λ). Therefore, if v_λ and v_k are primitively synchronous, designating Earth's semi-axis major by ρ_3,

$$\text{Sun's mass } (\mu_o) : \text{Earth's mass } (\mu_3) :: v_\lambda : v_k :: \frac{\rho_3}{497.827} : .56558 \text{ miles} \ldots (1)$$

If we designate Sun's and Earth's densities, respectively, by δ_o and δ_3.

$$\mu_o : \mu_3 :: \left(\frac{\rho_3}{214.45}\right)^3 \delta_o : r_3^3 \delta_3 \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (2)$$

$$\delta_3 : \delta_o :: \left(2\pi\sqrt{\frac{r_o}{g_o}}\right)^2 : \left(2\pi\sqrt{\frac{r_3}{g_3}}\right)^2 :: (10049)^2 : (5073.6)^2 :: 1 : .2549 \ldots (3)$$

Substituting (3) in (2) we find, by elimination between (1) and (2),

$$\mu_o = 328{,}424\ \mu_3.$$
$$\rho_3 = 92{,}472{,}100 \text{ miles.}$$
$$r_o = \rho_3 \div 214.45 = 431{,}206 \text{ miles.}$$

57. *Convertibility of Natural Units.*

Stoney's notation, with the modifications proposed in Note 47, connects the electric and photic units through the equation :

$$v_o = L_o \div T_o = I \div i = e \div E = (C \div c)^{\frac{1}{2}} = (r \div R)^{\frac{1}{2}}.$$

The gravitating, photic, thermal and electric units are, therefore, interconvertible by the equation

$$G_o T_o = v_\lambda = \frac{\mu_o}{\mu_3} v_k = v_o = 185{,}751.6 \text{ miles} = 298{,}930 \text{ kilometres.}$$

It seems probable, in view of the mean result of my other physical investigations, that the above values of μ_o and ρ_3 may be, respectively, about one per cent., and $\frac{1}{4}$ of one per cent., too small. If the calorie and J were estimated at the equator, the approximation would probably be still closer and, perhaps, exact.

58. *Solar Temperature.*

The infinitely projectile or radiating power of a central mass varies as $\sqrt{2gr} \propto \sqrt{\frac{\mu}{r}}$. When the comparison of mutual solar and terrestrial actions and reactions is made through their common radius or semi-axis major, $\sqrt{\frac{\mu}{r}} \propto \sqrt{\mu} \propto \sqrt{v_\lambda}$. As v_k is the thermal equivalent-velocity at Earth's surface for 100° C., we may infer that the mean radiating temperature, at Sun's surface, is $g_3 \times 100° \times \sqrt{328{,}424} = 27.739 \times 57308° = 1589590°$ C. The temperature deduced from Sun's semi-diameter (r_o) is $\frac{r_o}{1389.6 \text{ ft.}} = 1638430°$ C., being 1.0307 times the value which is indicated by the mutual actions and reactions of solar and terrestrial mass. This approxi-

mation would be very satisfactory, even without attempting to account for the discrepancy. It is of the same order of magnitude as the orbital projections of the planets, and it represents, very closely, the *vis viva* of Jupiter's secular apsidal oscillation. For the ordinary thermal equivalent varies as the square of the corresponding velocity, or as the fourth power of orbital velocity. The fourth power of 1.0307 is 1.1287; Jupiter's secular *vis viva* of projection, according to Stockwell,* is $\frac{1.06083}{.93917} = 1.1296$.

59. *Permanency of Standards.*

The three controlling masses, at the nebulous centre, the nucleal centre, and the centre of condensation, exert a combined thermodynamic influence which may lend interest to a closer examination of the several interconvertible standards (Note 57). It is noteworthy, at the outset, that they are all maxima; G_o representing the greatest gravitating energy in the solar system; T_o, the cyclical time of maximum disturbance of the centripetal tendencies of G_o; $v_A = v_e$, the greatest known velocity of wave-propagation; μ_o, the greatest mass in the solar system; μ_3, the mass which exercises the greatest local influence upon the physical phenomena which are susceptible of the most minute observation; v_k, the greatest thermal range between the centripetal and centrifugal forms of the most widely diffused and most important body which is well known in the three states of solid, liquid and gas; $L_o = G_o T_o^2$, the sum of the accelerations of G_o during T_o. The law of conservation of areas, as well as the law of constancy, requires that G_o should vary inversely as T_o, in all stages of solar nebular condensation. The photic unit, v_A, on account of the abundant evidence of its universal activity, as well as on account of the laws of equal action and reaction, and of the inverse variability of elasticity and density in homogeneous media, is presumably invariable. The thermal unit, v_k, is practically constant, but its dependence upon relations of mass which may be subject to slight, though inappreciable, variations, subordinates it to the photic unit. The electric unit, v_e, being identical with the photic unit, the question arises, which of the two should be regarded as primary, and which as secondary. Do not the facts that light is universal, while the various electrical units represent local relations, indicate the proper answer?

60. *Heat and Electricity.*

The probability of arriving at the unity of force through the study of æthereal oscillations, was indicated by me in 1864.† The special relations of electricity to heat, which Edlund subsequently discussed with great ability and fullness, are shown by the proportions,

$$\left(\frac{I}{i} = \frac{e}{E} = \sqrt{\frac{C}{c}} = \sqrt{\frac{r}{R}} = \frac{L_o}{T_o}\right) : v_k : : \mu_o : \mu_3.$$

$$C : c v_k^2 : : r : R v_k^2 : : \mu_o^2 : \mu_3^2.$$

*Smithsonian Contributions, 232, p. 38.

†Proc. Am. Phil. Soc., lx, 356-60.

61. *Photo-thermal Unit.*

Since temperature varies as the square of the velocity, we have,

$$v_k^2 : v_A^2 :: 100° : x.$$
$$.56558^2 : 185,751.6^2 :: 100° : 10786240000000°.$$

The corresponding projectile abscissa may be found, in terms of Sun's semi-diameter, by multiplying by 1389.6 and dividing by r_o, (Note 56); $1389.6 \times 10,786,240,000,000 \div (431,206 \times 5280) = 6583265$; log. 6583265 $= 6.8184413$. This agrees, within less than $\frac{1}{7}$ of one per cent., with the photodynamic determination of the third centripetal abscissa in the stellar-solar paraboloid, (log. $A_{37} = 6.8190131$, Note 46).

62. *Thermo-gravic Paraboloid.*

By taking $\frac{1}{2} r_o$, $\frac{4}{3}$ L, and A_{37} as the paraboloidal elements, we substitute the thermal for the photic aspect of the æthereal waves and are enabled to compare gravitating actions with thermal reactions. We thus find,

$$\text{Log. } \eta = -.001788316$$
$$\text{Log. } \zeta = .0055973414$$

The closeness of agreement between the photic and thermal abscissas is shown by the following comparisons:

		Locus.	Photic.	Thermal.	Difference.
A_{21}	$\frac{1}{2}$	Mercury,	1.6527576	1.6527216	.0084 of 1 per cent.
A_{29}	$\frac{7}{8}$	Neptune,	3.8776006	3.8773517	.0578 " "
A_{39}	a	*Centauri*,	7.6663303	7.6656606	.156 " "

The greatest difference is, therefore, less than $\frac{1}{2}$ of one per cent. The photo-thermal unit (A_{28} = L M, see Note 46), is intermediate between the photo-gravic unit (A_{37}), and the stellar locus (A_{39}). We have thus five elementary loci where only three are required. By equations of condition we ought to be able to determine all the values which are involved, with much greater accuracy than will ever be possible by astronomical observations.

63. *Unity of Force.*

The belief that all forms of force are modifications of one fundamental energy, is as old as the oldest Greek philosophy, but no approximation towards a demonstration of the belief seems to have been made until Rumford performed his experiments at Munich, in 1798. During the present century, the undulatory theory of light has commanded a general acceptance, the science of thermodynamics has been largely developed, and Tyndall's works have made the reading world familiar with the proofs that heat is a mode of motion. Stephenson taught that the energies of sunlight were stored in vegetable growths and in coal-beds; Herschel called attention to the enormous elasticity of luminiferous æther and to the Sun's rays as "the ultimate source of almost every motion which takes place on the surface of the earth;" Titius, Bode, Alexander and Kirkwood, presented evidences of law in planetary arrangement; Peirce and Hill found similar

evidences in times of planetary revolution; Faraday strove in vain to reconcile the law of gravitation with the theory of conservation of energy; Weber and Kohlrausch introduced a general kinetic notation and found the importance of the velocity of light in electrical phenomena; Faraday discovered the magnetic influence upon light and Sir William Thomson stated that "the explanation of all phenomena of electromagnetic attraction or repulsion, and of electromagnetic induction is to be looked for simply in the inertia and pressure of the matter of which the motions constitute heat;" Maxwell* considered magnetic force as the effect of the centrifugal force of vortices, electromagnetic induction as the effect of the forces called into play when the velocity of the vortices is changing, electromotive force as arising from the stress on the connecting mechanism, and electric displacement as arising from the elastic yielding of the connecting mechanism.

64. *Reclamation.*

In 1863, I began a systematic series of investigations, in the hope of *verifying, by numerical measurements*, some of the supposed consequences which seemed to flow from the foregoing researches and hypotheses, and of *finding new clues* to the values and relations of the fundamental elements of physical energy. The division of forces into attractive and repulsive, as well as the equality of action and reaction led me to the study of the laws of elasticity and their influence on undulatory and cyclical motions. In my first paper† I called attention to the effects of cyclically alternating acceleration and retardation during rotation or revolution. In the course of the seven following months, I pointed out various relations which seemed to have been previously unnoticed, between heat, gravitation, electricity and magnetism, showing that many of the phenomena could be imitated and explained by the mechanical propagation of vibrations. The tendencies to equilibrium between gravitating pressure and æthereal elasticity, the necessary production of continual oscillations by opposing forces, the possibility of accounting for gravitation, electricity and magnetism by such oscillations moving with the rapidity of light, were all discussed during this period.

65. *Musical Rhythm.*

Fourier (Note 33) seems to have first given a mathematical demonstration of the *necessity* that cyclical motions should be also rhythmical. If the luminiferous æther is anything more than a hypothesis, which helps to explain an indefinite variety of phenomena, the tendency to the production of harmonic nodes in elastic media must greatly multiply the rhythmical manifestations, both cosmical and molecular. Some of those harmonies have long been known, their discovery having been apparently the result of accident, or of a happy guess. The number which will hereafter be made known will depend, in large measure, on the skill with which

* Electricity and Magnetism, II, 417.
† Proc. Am. Phil. Soc., ix, 285, Dec. 1863.

lines of investigation are guided by an understanding of the influences and consequences of elastic action and reaction.

66. *Mass, Distance and Time.*

Laplace regarded force as proportional to velocity, treating momentum, or the product of mass by velocity, as the result of force acting on mass. He defined velocity as "the ratio of the space to the time employed in describing it." More recent writers consider force as equivalent to *vis viva*, involving both matter and motion, and represented by one-half the product of mass by the square of velocity, $\frac{mv^2}{2}$. Often, however, they follow Laplace in treating velocity as a ratio, designating distance or length by l, and time by t. The symbols m, l, t, therefore, are applicable in all discussions of force, and their use has paved the way for a ready acceptance of any evidence which may be adduced respecting the substantial unity of force. The fluctuating and arbitary values which have been assigned to the symbols, and the lack of any universally recognized standards of measurement, have obstructed the discovery of evidence without weakening the belief in kinetic unity. Even the recognition of a common velocity, in light and electricity, seems to have led to no systematic search for common standards of length and time.

67. *Maxima, Minima and Means.*

In all ordinary investigations, in any special department of dynamics, we deal with observed values which have a limited range, with a view of finding the most probable mean. In the study of forces which vary in accordance with known or supposed law, minimum or vanishing values claim special consideration. For a full understanding of any force we must also know the greatest energy of which it is capable, or of which we can obtain any practical experience. If we wish to compare different kinds of force, in order to ascertain the character of supreme and controlling energy, it seems especially important that we should turn our attention, at the outset, to the greatest manifestations of each of the elements of energy, m, l, t.

68. *Light and Electricity.*

For a long time, little was known of electricity except the phenomena of attraction, repulsion, and luminous manifestation. Faraday's want of success in searching for some bond of union between electricity and gravitation, deterred others from continuing the search. The undulatory theory of light enabled Weber and Kohlrausch to make their first determination of a velocity, which serves to connect many electrostatic and electromagnetic phenomena, and which is of the same order of magnitude as the velocity of light, v_λ. Their subsequent investigations, together with those of Thomson, Maxwell, Ayrton and Perry, showed that the two velocities are not only of the same order of magnitude, but that they are

probably identical, so that light and electricity may be properly regarded as different modifications of a more fundamental energy. Their common velocity is the greatest known velocity of wave-propagation, and we are thus further encouraged to the study of maxima as indications of kinetic unity. The elements l, t, and m are still arbitrarily assumed in electrical treatises, notwithstanding the suggestiveness of the well-known equation of wave-velocity, $v = \sqrt{2gh}$.

69. *Electrostatic and Electromagnetic Dimensions.*

Although arbitrary values have been assigned to m, l and t, in electrical discussion, the same values are generally assumed in electrostatic and electromagnetic comparisons. It has thus been found that the ratio between the two systems is the velocity of light for quantity of electricity, electric current, magnetic potential, electric displacement, surface density, magnetic force, strength of current at a point, quantity of magnetism, electrokinetic momentum of a circuit, line-integral of electromotive force, magnetic induction, electromotive force at a point, and vector potential. The ratio is the square of the velocity for electrostatic or electromagnetic capacity, dielectric or magnetic inductive capacity, conductivity and resistance. The product of these two ratios by mass, furnishes indications of momentum and *vis viva* which will doubtless be useful in many general kinetic comparisons.

70. *Heat and Gravitation.*

The direct opposition of tendencies in heat and gravitation, the former being centrifugal and the latter centripetal, leads to an easier and more direct means of comparison between the two energies than has been found in the case of light and electricity. But the adoption of mh or $\frac{ml}{2}$, as the mechanical equivalent of heat, leaves the relation of gravitation out of view, and it is not readily seen until we find that $mh = \frac{2m}{g} \times \left(\frac{h}{t}\right)^2$. Even then, the foot-pound and second, or the kilogrammetre and second, are such arbitrary values that there is no indication of any uniform standard like the velocity of light. We see, on further examination, that our knowledge of heat is wholly derived from phenomena at the Earth's surface, where terrestrial gravitation is a maximum, and we are thus led to accept Earth's mass as a fitting natural unit of mass in thermodynamic questions, especially in all questions which involve the factor $\frac{2m}{g}$. In order to reach kinetic unity, some values should be found for l and t which can be presented under some simple relation to the velocity of light.

71. *Central Energy of the System.*

We are now somewhat prepared to appreciate the reasoning of Herschel and Stephenson, in referring all terrestrial energies to the Sun, and to ac-

cept M_o and G_o, or Sun's mass and superficial gravitation, as standards of comparison between Sun's centripetal and centrifugal, or gravitating and radiating energies. The Sun itself is subject to the paramount control of universal mass and gravitation. Although we have no means of finding their absolute or relative value, we may symbolize them by M_u and G_u and thus seek for standard values of L_o and T_o. Every particle of the Sun is continually solicited by G_o and G_u, and their varying solicitations can be compensated only by cyclical alternations of rise and fall, from and towards the universal centre of gravitation, c_u. In order that Sun's mass may be stable, the sum of the tendencies of G_o must be equal to the sum of the tendencies of G_u, during each half-rotation. A solar half-rotation, therefore, may be taken as a natural standard value for T_o; then the equation $M_o H_o = \frac{2 M_o}{G_o} \times \left(\frac{H_o}{T_o}\right)^2$ gives $H_o = \frac{G_o T_o^2}{2}$, and $L_o = 2 H_o = G_o T_o^2$ as a corresponding natural standard of length and distance.

72. *Standard Kinetic Modulus.*

If we examine the equation which we have found in the foregoing note for the natural unit of length, we find that H_o represents the height of virtual fall which would give a velocity equivalent to $G_o T_o$, and L_o is the height of a homogeneous elastic atmosphere which would have a velocity of wave-propagation equivalent to $\frac{L_o}{T_o} = G_o T_o = G_u T_o$, the actions and reactions of G_o and G_u being equal. But the elastic atmosphere, in which these actions and reactions take place, is the universal æthereal medium, and its velocity of wave-propagation, $\frac{L_o}{T_o}$, is the velocity of light. The relations of heat, mass and gravitation, therefore, lead us to the same fundamental velocity as the relations of the electrostatic and electromagnetic systems, and the same velocity as the solar radiations which are variously modified so as to produce the phenomena of light, heat, electricity, magnetism and actinism. Our knowledge of the significance of the electrical unit is thus extended, so as not only to include the ratio $\frac{L_o}{T_o}$, but also to show that the natural standard units of mass, length, and time are, respectively, M_o = Sun's mass; L_o = standard kinetic modulus, or Solar modulus of light; T_o = half-time of solar rotation, or time of cyclical equality of action and reaction between solar inertia and æthereal undulation.

73. *Variable Units.*

In comparing arbitrary and variable units with the maximum standards, we have generally to deal with fractional values. In uniform velocities, like those of light, electricity, and primitive kinetic radiation, $l \propto t$; in variable velocities which are due to centripetal or centrifugal radiation, like those of gravitation and heat, $l \propto t^2$. Maxwell* gives electric di-

*Op. cit., II, § 620-9.

mensions and formulas which can be readily converted into standard kinetic units; gravitating formulas can be similarly converted through the correlations, $g \propto \frac{m}{p} \propto \frac{l}{t^2}$, $\sqrt{g r} \propto \left(\frac{m}{l}\right)^{\frac{1}{2}}$; thermal formulas, through the correlations, $w \propto [m]\ h \propto [m]\ v^2 \propto [m]\ \frac{p}{t^2}$.

74. *Complex Variability.*

Any variable unit may be dependent upon some other variable unit, and different values of m, l and t may thus be involved in the same expression. It is necessary, therefore, that the significance of every variable symbol should be fully understood before undertaking to convert it into terms of the corresponding standard unit. For example, in the thermal and electric formulas, $[m]$ refers to the mass which is lifted against the constant pull of gravity, while in thermal formulas v, l and t also introduce considerations which are dependent upon the centripetal energy of Earth's mass, m_3, at a constant distance. The conversion of thermal into standard formulas, therefore, requires due attention to the ratios both of $[m]$ and m_3 to M_0. In such cases it may often be well to introduce a second natural unit, which can be simply derived from the standard unit, as in the deduction (Note 56) of the terrestrial thermal unit of velocity from the solar unit of luminous velocity, $v_k = \frac{m_3}{M_0} V_0 = m_3 M_0^{-1} L_0 T_0^{-1}$.

75. *Notation and Approximate Values.*

Let r_a = Sun's apparent semi-diameter $\doteq$* 961.″83	2.9830990
$n = r \div r_a \doteq 214.45$	2.3313261
r_0 = Sun's semi-diameter $\doteq$ 431,208 miles	5.6346866
$\rho_3 = n r_0$ = Earth's semi-axis major $\doteq$ 92,472,500 miles	7.9660127
r_3 = Earth's semi-diameter $\doteq$ 3962.8 miles	3.5980022
p_0 = Sun's parallax $= \frac{r_3 r_a}{r_0} \doteq 8.''8392$	.9464146
$t_0 = 2\pi (r_0 G_0^{-1})^{\frac{1}{2}} = 1$ year $\div n^{\frac{3}{2}} \doteq 10049$ seconds	4.0021223
$t_3 = 2\pi (r_3 g_3^{-1})^{\frac{1}{2}} \doteq 5073^s.6$	3.7053158
d_0, d_3 = density of Sun, Earth	
$\frac{d_0}{d_3} = \left(\frac{t_3}{t_0}\right)^2 \doteq .25491$	$\bar{1}$.4063870
l_0 = Laplace's limit $= n\left(\frac{2 T_0}{1 \text{ yr.}}\right)^{\frac{2}{3}} \doteq 36.3658\ r_0$	1.5606934
$V_0 = \frac{L_0}{T_0} = \rho_3 \div 497.827 \doteq .4307721\ r_0$ = velocity of light.	$\bar{1}$.6342476
$v_0 = 2\pi r_0 \div t_0 \doteq .0006252556\ r_0$	$\bar{4}$.7960576
$v_k = (2 g_3 \times 180 \text{ J} \div 1 \text{ lb.})^{\frac{1}{2}} \doteq .56558$ miles	$\bar{1}$.7524940

**Nearly* equal. The right hand column contains the approximate logarithms.

$g_3 = 32.088$ ft. $\doteq .0060773$ miles.....3.7837087
$G_0 = v_0^2 \div r_0 \doteq .0000003909446\, r_0$.....7.5921152
$T_0 = V_0 \div G_0 \doteq 1101875$ seconds.....6.0421324
$L_0 = V_0\, T_0 = (V_0 \div v_0)^2\, r_0 \doteq 474657\, r_0$.....5.6763800
$M_0 = V_0 \div v_k = r_0^3\, d_0 \div r_3^3\, d_3 \doteq 328438\, m_3$.....5.5164402

Substituting the value of r_0 we find,

$l_0 \doteq 15{,}681{,}230$ miles..... 7.1953800
$V_0 \doteq 185{,}752$ miles..... 5.2689342
$v_0 \doteq 269.615$ miles..... 2.4307442
$G_0 \doteq 890.1$ ft. $\doteq .16858$ miles..... $\bar{1}$.2268018
$L_0 \doteq 2213.37\rho_3 \doteq 73.67$ Neptune's semi-axis major $\doteq$ 204,675,900,000 miles.....11.3110666

76. *Vis viva of Wave Propagation.*

In 1857, Professor Stephen Alexander announced to the American Association the approximate equality of md^2 in the two planets, Jupiter and Saturn, which make more than $\frac{1}{1}\frac{2}{0}$ of the aggregate planetary mass in our system. He also showed that the mean distance of Saturn is nearly equivalent to $\frac{2}{3}$ of Jupiter's mean distance, and that the ratio $\frac{2}{3}$ has been largely influential in planetary distribution. In 1872, I showed* that the same ratio may be deduced from the thermal energy of chemical combination, representing the ratio of mean *vis viva*† of oscillating particles to *vis viva* of wave propagation. In 1877, Maxwell and Preston‡ published the same ratio, without seeming to have known that I had already deduced it from the laws of kinetic oscillation in elastic media. Its importance in discussions of kinetic unity, is evident from the fact that it is alike operative in the establishment of cosmical§ and of molecular harmonies.

77. *Conical Pendulums.*

The tendencies to concentration, through the mutual attractions of particles which are subjected to a simultaneous linear projection, and other combinations of tendencies to uniform and to variable velocities, lead to many oscillations which follow the laws of conical pendulums. It is therefore important, in investigations which involve cyclical elastic action, to inquire what forms of pendulum-vibration will best fulfil the requirements of Fourier's theorem. The general formula for the velocity of a conical pendulum is,

$$v = \sqrt{gr \sin\theta \tan\theta}.$$

Hence, since $t = 2\pi r \sin\theta \div v$, we find

$$t = 2\pi \sqrt{\frac{r}{g} \tan\theta}.$$

* Proc. Am. Phil. Soc., xii, 392-4.
† Ib. foot note.
‡ P. Mag. [5], iii, 453; iv, 299.
§ Proc. A. P. S., xii, 403-5, *et seq.*

This is equivalent to twice the time of vibration in a simple pendulum of the same height, ($\cos\theta$), or to the time of vibration in a linear pendulum of four times the height. The requirements of *vis viva*, synchronism, and the conversion of wave-propagating velocity into velocity of oscillation under central action, are all satisfied, as I have shown in my discussions of explosive energy (Note 16, *et al.*), by combining the ratios of this and the foregoing note, $\frac{1}{4} \times \frac{5}{6}$.

78. *Standard Temperatures.*

In thermodynamic deductions and comparisons, it is often important to decide what temperature should be taken as the standard. Whenever a sufficient number of kinetic values have been deduced for the natural units, M_o, L_o, T_o, the introduction of conditioning equations may help us to much accurate and useful knowledge which will lead to greater precision in many details of molecular physics. The present range of uncertainty may be estimated by examining the influence of two different possible standards upon the results of Note 16. The combining calories appear to have been observed, in each instance, at the temperature of 15° C. To reduce the mean to 0°, we have

$$\begin{aligned} H_2 &= 2 \times 15 \times 3.409 &&= 102.27 \\ O &= 16 \times 15 \times .2175 &&= 52.20 \\ \text{Total deduction} &&&= 154.47 \end{aligned}$$

Leaving $68886 - 154.47 = 68731.53$ calories

$$\tfrac{5}{6} \times \tfrac{1}{4} \times \tfrac{1}{6} \times 68731.53 \times \frac{1389.6}{5280} = 279.15 \text{ miles} = h_1.$$

On the other hand, if we take the mean between the freezing and boiling points, as in Note 75, we find

$68886 + \frac{13}{15}$ of $154.47 = 69246.43$ calories, representing $h_2 = 281.24$ miles.

h_1 gives $m_o = 332{,}693\ m_1$; $nr = 92{,}871{,}000$ miles.
h_2 " $m_o = 328{,}989\ m_1$; $nr = 92{,}525{,}000$ miles.
Note 75 $m_o = 328{,}438\ m_1$; $nr = 92{,}472{,}500$ miles.

79. *Factors of Vis Viva.*

Although ordinary kinetic investigations involve considerations both of mass and velocity, the equality of action and reaction furnishes data, in many cases, for dispensing with one of the three kinetic units. For example, the equation of circular orbital revolution, $v = \sqrt{gr} = \sqrt{\frac{m}{r}}$, may be put in the form $\frac{l}{t} = \frac{\sqrt{l'\,l''}}{t} = \frac{\sqrt{\tau d}}{t}$, and we may use either of the equivalent values without vitiating our results. The meaning of the mass-factor is especially obscure in the "dimensions of electric units," but when we see that m is regarded as the product of electrostatic $m^{\frac{1}{2}}$ by electromagnetic $m^{\frac{1}{2}}$, and when we remember the importance of Ampere's

theory of currents, we are reminded of the orbital equations, and if we still think of mass, it is only because we have learned to regard mass as a necessary element of force. If we look still further, and see that the product of two masses must be considered in order to secure strict accuracy in the determination of orbits, we can find no good meaning for the square root of a mass. But if electric phenomena are simply the result of oscillations in the luminiferous æther, which represent the actions and reactions of inertia and elasticity, we may reasonably look for analogous phenomena in cosmical arrangements.

80. *Cosmical Illustration.*

In the mutual actions and reactions of two masses, $v = \sqrt{gr} \propto \sqrt{\frac{m}{r}} \propto \sqrt{m}$;* $v^2 \propto m$; $\frac{m}{v} \propto v$. Let m_0, m_3, m_5 designate Sun, Earth, Jupiter; v_3, Earth's aphelion velocity; v_λ, velocity of light. Then we find

$$\frac{m_0}{v_\lambda} : \frac{m_3}{v_3} :: \frac{m_3}{v_3} : \frac{m_5}{v_\lambda}$$

For, $v_\lambda = \rho_3 \div 497.827$; $v_3 = 2\pi\rho_3 \div 1.01677 \div 31558149$; $m_0 = 1047.879\, m_5$. Substituting these values, we find: $m_5 = 316.9\, m_3$; $m_0 = 332,072\, m_3$; $\rho_3 = 92,559,700$ miles. Hence we see that the reaction of Earth against the forces which produce its orbital velocity, at the moment when it is least affected by Sun, is a mean proportional between the reactions of Sun and Jupiter against the velocity of light. In other words, the reaction of inertia at the centre of density (Earth) against the inertia at the centre of nebulosity (Jupiter) and at the centre of nucleation (Sun) is limited in each direction by the reactions of controlling inertia against æthereal elasticity.

Multiplying the terms of the above proportion by $v_\lambda^2 v_3$, we have

$$m_0 v_\lambda v_3 : m_3 v_\lambda^2 :: m_3 v_\lambda^2 : m_5 v_\lambda v_3.$$

The importance of the reactionary *vis viva* at the centre of condensation is thus shown, and the *vis viva* at the coördinate centres represents a mean proportional between the æthereal and the central orbital *vis viva*.

81. *Mutual Convertibility of Gravity and Magnetism.*

In the first set of electrostatic, magnetic and electrokinetic pairs, the product of the two dimensions represents an energy, or *vis viva*. Maxwell† gives the following equations:

$$[e\,E] = [m\,\Omega] = [p\,C] = \left[\frac{L^2 M}{T^2}\right].$$

The symbols denote, respectively, the products of quantity of electricity by electric potential, quantity of free magnetism by magnetic potential,

* Because r represents the distance between the two masses and does not affect the ratio.

† Elec. and Mag., II, 240.

electrokinetic momentum of a circuit by electric current, mass by the square of the velocity of light. *The last product is, therefore, precisely the same as* $m_3 v_\lambda^3$, *in the foregoing note*, and it furnishes further grounds for considering the primitive oscillations as luminous, rather than electric. There are as good reasons for assuming Earth's mass as the fundamental electric value of M, as for assuming the velocity of light as the corresponding value of $\frac{L}{T}$, and this assumption brings electric and thermal phenomena into simpler and more intelligible relations. The anticipations of my first paper* upon the relations of electricity and magnetism to gravitation are thus very fully and satisfactorily confirmed.

82. *Chemical Units.*

The influence of electric and thermodynamic laws on chemical phenomena has long been recognized. There are two special applications of electric dimension to which I would call attention, on account of their apparent bearing upon spectral harmonies and combining equivalents.

I. The second set of electrostatic, magnetic and electrokinetic pairs gives the following equations:

$$[\mathfrak{D}\,\mathfrak{E}] = [\mathfrak{B}\,\mathfrak{H}] = [\mathfrak{C}\,\mathfrak{V}] = \left[\frac{M}{L\,T^2}\right].$$

The symbols denote, respectively, the products of electric displacement by electromotive force at a point, magnetic induction by magnetic force, intensity of electric current at a point by vector potential of electric currents, and the dimensions of energy referred to unit of volume. The last member of the equation also represents the unit of density, or atomic weight of an element, and thus opens a wide field for investigation, both in chemical and in general physics.

II. Weber found, by experiment, that the unit of electro-chemical force is to that of electromagnetic force as $106\frac{2}{3}$ is to 1. Designating the electro-chemical unit by χ and the electromagnetic unit by μ, if we suppose them to vary inversely as the squares of the reacting velocities (Note 80), we find

$$\left(\frac{m_0}{v_\lambda}\right)^2 : \left(\pi\frac{m_3}{v_3}\right)^2 :: \chi : \mu :: 106.17 : 1.$$

This differs from Weber's experimental value by less than $\frac{1}{2}$ of one per cent. The π-factor designates the ratio between the time of acquiring atmospheric orbital velocity at Laplace's limit, t_a, and the time of acquiring nucleal dissociative velocity, t_n;

$$t_a : t_n :: 1 : \pi.$$

83. *Positive and Negative.*

The oppositions of solar and Jovian photodynamic reaction, which are shown in the first proportion of No. 80, may perhaps help towards a better

* Proc. Am. Phil. Soc., ix., 355-60; April 1, 1864.

understanding of the difference between positive and negative electricity, or austral and boreal magnetism. While the action of æthereal oscillations must be modified by every centre of inertia, whether cosmical or molecular, the reactions of Sun and Jupiter must always greatly preponderate. In analyzing the product of the reactions into electrostatic and electromagnetic elements, $M^{\frac{1}{2}}$ may be considered as representing a mean proportional between the positive and negative masses. Reasoning from analogy, it seems probable that the electric M may represent a product, and $M^{\frac{1}{2}}$ a mean proportional, in all cases.

84. *Sun-Spots and Planets.*

The evidences of connection between sun-spots and planetary perturbations, the phyllotactic rhythm in periods of planetary revolution which was pointed out by Peirce and Hill,* the twelve harmonic nodes between Mercury and Sun of which I have already given evidence,† the relations of "magnetic storms" to sun-spots and to auroras, the confirmation of my first intra-Mercurial node by the British sun-spot observations,‡ as well as the various indications of a possibility that Swift's and Watson's planets may have been transient nodal aggregations, all seem deserving of consideration in studying the actions and reactions among the various forms of kinetic energy.

85. *Stellar relations of Central Density.*

In the stellar-solar paraboloid the abscissa which indicates Earth's nebula-rupturing locus, is also the locus of solar-rupture in subsidence-collision. The multiples 3, 4, 5, appear as coefficients, either of incipient subsidence or of final rupture or of both, for Earth, Mars, mean asteroid and Jupiter, their rupturing loci being, respectively, $\frac{3}{5}$, $\frac{4}{5}$, $\frac{4}{5}$, $\frac{5}{6}$ of their semi-axes major. The corroboration of the importance of Earth's position at the centre of density, which is furnished by Note 80 *et seq.*, is strengthened by the following multiple relations of Earth's semi-diameter, r_3:

1	$(3 \times 4 \times 5) \times r_3 \doteq$ Moon's semi-axis major.
2	$(3 \times 4 \times 5)^2 \times r_3 \doteq$ Perigee of Venus.
3	$(3 \times 4 \times 5)^3 \times r_3 \doteq$ Saturn's semi-axis major.
4	$4\,(3 \times 4 \times 5)^4 \times r_3 \doteq$ Solar modulus of light.
5	$2\pi\,(3 \times 4 \times 5)^5 \times r_3 \doteq$ Distance of *a Centauri*.

The deviations are of the same order of magnitude as planetary eccentricities, being as follows: 1, about $\frac{1}{2}$ of one per cent.; 2, nearly $2\frac{2}{3}$ per cent.; 3, nearly 3.4 per cent.; 4, less than $\frac{1}{21}$ of one per cent.; 5, less than $3\frac{2}{3}$ per cent. The fourth locus is equivalent to the *latus rectum* of a paraboloid in which modulus is the focal abscissa; the fifth is $\frac{\pi}{2}$ of $(3 \times 4 \times 5)$

* Proc. Amer. Assoc., v, 2.
† Proc. Am. Phil. Soc., xix, 367.
‡ Ib., xiii, 470.

$\times$ the fourth, $\frac{\pi}{2}$ being the ratio of circular-orbital velocity to mean velocity of synchronous radial oscillation.

86. *Prime Centres of Energy.*

In considering the photodynamic reactions of Sun against the æthereal oscillations, reference has been had to Sun's centre of gravity, C_o. In my first paper* on the influence of cyclical oscillation, I anticipated the possibility of measuring fluctuations which are produced by the Central Sun. The first step in that direction was the discovery of the stellar-solar paraboloid, by means of the rupturing tendencies which would result from Herschel's theory of "subsidence," in a nebulous elastic medium. The next step was the investigation of the relations of the solar centre of gravity to the universal centre of gravity, C_u, which are involved in the cyclical equilibrium of æthereal and gravitating energies. It is perhaps possible for mathematical analysis to find some approximation to the mass and distance of the controlling centre of the immediate stellar group to which we belong, from known data. In seeking such approximation, regard should evidently be paid to the motions of the centre of gravity of the solar system, C_a. The next centre in point of importance is, perhaps, the centre of condensation in the solar system, C_β.

87. *Projection of Centres of Nucleation, Nebulosity and Condensation.*

It may be assumed that the mean centre of gravity of our system, C_a, is the same as the mean centre of gravity of its two chief masses, Sun and Jupiter. Jupiter's semi-axis major, ρ_5, is equivalent to $5.202796\rho_\beta$. Sun's mass, m_o, is 1047.879 times Jupiter's mass, m_5. Sun's semi-axis major, ρ_a, or mean projection from C_a, is therefore $\frac{5.202796\rho_\beta}{1+1047.879}$, or $.0049603\rho_\beta$. Stockwell's estimate† of the secular maximum eccentricity of Jupiter is .060874, which represents a rupturing projection, for C_a, of $\frac{1}{1-.060874} = 1.0648r_o$. The equation, $.0049603\rho_\beta = 1.0648r_o$, gives $\rho_\beta = 214.667r_o$; $n = 214.667$. This is about $\frac{1}{10}$ of one per cent. greater than the estimate of the British Nautical Almanac, and about $\frac{1}{10}$ of one per cent. less than that of the American Nautical Almanac.

88. *Orbital and Nascent Energies at the Centre of Condensation.*

The evidences of photodynamic projection, which were presented in Note 80, together with other evidences of the importance of Earth's mass and semi-diameter, as secondary thermal and electric units, enable us to connect orbital velocity, v_a, with nascent or dissociative velocity, v_β, at the centre of condensation, Earth. For, since distance or *vis viva* of projec-

* Proc. Am. Phil. Soc., 1x, 288.

† Smithsonian Contributions, 232, p. 38.

tion against uniform resistance varies as the square of the time of communicating or overcoming the velocity of projection, we find the proportion: Sun's projectile locus or semi-axis major, ρ_α, *is to* Earth's projectile locus or semi-axis major, ρ_β *as* the square of the time of communicating orbital velocity, t_α^2, *is to* the square of the time of communicating nascent or dissociative velocity, t_β^2. Assuming the values, $\rho_\alpha = 1.0648 r_o$, $\rho_\beta = 214.667 r_o$, in accordance with the foregoing note, and remembering that t_β is always the time of a half rotation, we have

$$1.0648 : 214.667 :: t_\alpha^2 : 43082^2$$

$$t_\alpha = 3034.25 \text{ sec.}$$

$$v_\alpha = 3034.25 \times 32.088 \div 5280 = 18.44 \text{ miles.}$$

$$\rho_3 = 18.44 \times 31558149 \div 2\pi = 92,617,300 \text{ miles.}$$

89. *Double Systems of Photodynamic Oscillation.*

In 1864, I suggested* "that one of the most probable results of the rotation of the earth with its atmosphere, in an æthereal medium, would be the production of two systems of oscillations, moving with the rapidity of light, one in the line of the Earth's orbit, and the other in the line of its radius vector, and that those systems would be constantly so related that while one tended to retard, the other would tend to accelerate the Earth's motion." In 1866, I showed† that "the velocity of light is nearly the same as the velocity which would be acquired in one year by a falling body, under the influence of an accelerating force equivalent to the force of gravitation at the Earth's surface." Although I regarded this approximation, at first, as "perhaps merely a curious accidental coincidence," it became so prolific in suggestive leadings that I was able to show its dependence upon simple dynamic laws of æthereal condensation. From the electrostatic analogies of condensation and the electrokinetic analogies of orbital motion, we may infer the probable applicability of the law of energy and stress of radiation, "that at every point of the wave the intrinsic energy of the medium is half electrostatic and half electrokinetic."‡ At the locus of primitive coincidence between orbital and rotary velocity, this division of energy would lengthen the time of acquiring the solar nascent dissociative velocity of light to a complete rotation of the centre of condensation, the time for the nucleus being a half-rotation. Dividing one year by the square root of the ratio of solar photodynamic projection (Note 88), we find 31558149 seconds $\div \sqrt{1.0648} = 3058254$ sec.; $v_\lambda = 3058254g = 185,858$ miles; $\rho_3 = 497.827 v_\lambda = 92,525,300$ miles. This differs by less than one-tenth of one per cent. from the value given in the foregoing note.

* Proc. Am. Phil. Soc., ix, 408.

† Ib., x, 269.

‡ Maxwell, ii, 391.

90. *Formulas for Conversion of Energy.*

All forms of energy, mechanical, thermal, photic, electric, magnetic or chemical, are derived from and can be compared with the maximum energy, $\frac{M_\circ L_\circ^2}{T_\circ^2}$.

a. All astronomical, barometric, or other mechanical estimates of solar mass and distance, involve the proportionality, $g \propto \frac{m}{l^2}$.

β. The arbitrary units of thermodynamics are based upon the work done against the centripetal accelerations of terrestrial gravity. The unit of acceleration at unit of distance, or the sum of accelerations in unit of time, is proportioned to mass. Therefore, if we designate Earth's mass by m_3, we have $M_\circ : m_3 :: V_\circ : u_3$.

$V_\circ$, or the velocity of light is, as we have seen, the velocity acquired during the cyclical actions and reactions of solar condensation and æthereal elasticity at Sun's surface; $u_3 = .56558$ miles, is the velocity acquired during the cyclical actions and reactions of water-congelation and evaporation at Earth's surface. Dividing by $\sqrt{180}$ for the Fahrenheit scale, or by $\sqrt{100}$ for the Centigrade scale, we have the arbitrary units of velocity, .042156 miles for 1° F., or .056558 miles for 1° C. The equation $v = \sqrt{2gh}$ gives $h = 772$ ft. for 1° F. or 1389.6 ft. $= 424$ meters for 1° C. Combining these heights with the arbitrary units of mass we have J = 772 ft. lb. for the English thermal unit, and C = 424 kilogrammetres for the calorie or French thermal unit.

γ. Thermal, mechanical and photodynamic energies may be compared with energies of chemical combination through the ratio

$$M_\circ : m_3 :: V_\circ : u_3 :: h_\circ : h_2.$$

$h_\circ$ is Earth's mean distance from Sun, h_2 is $\frac{1}{4}$ of $\frac{5}{9}$ of the height to which water-vapor would be thrown, against the retardation of gravity, by the combining energy of H_2O (Note 16, etc.).

δ. Cosmical, electric and photodynamic energies may be compared by means of the ratio

$$M_\circ V_\circ v_3 : m_3 V_\circ^2 :: m_3 V_\circ^2 : m_5 V_\circ v_3.$$

Sun, $M_\circ$, is at the centre of nucleation in the solar system; Earth, m_3, at the centre of condensation; Jupiter, m_5, at the nebular centre; v_3, is Earth's aphelion or "nascent" orbital velocity.

ε. The electrostatic, magnetic and electrokinetic units of energy can all be derived from the above expression for Earth's photodynamic energy, $m_3 V_\circ^2 = \frac{m_3 L_\circ^2}{T_\circ^2}$, through the equations

$$[e\,E] = [m\,\Omega] = [p\,C] = \frac{M L_\circ^2}{T_\circ^2}$$

The bracketed symbols represent, respectively, quantity of electricity; line integral of electromotive force, or electric potential; quantity of free

magnetism, or strength of a pole; magnetic potential; electrokinetic momentum of a circuit; electric current.

ζ. Atomic energy, or energy of unit volume, can be compared with Earth's photodynamic energy of unit volume, $\frac{m_3 L_0^2}{r_3^3 T_0^2} = \frac{m_3}{L_1 T_0^2}$, and with corresponding electric energies, through the equations

$$[\mathfrak{D}\,\mathfrak{E}] = [\mathfrak{B}\,\mathfrak{H}] = [\mathfrak{C}\,\mathfrak{A}] = \frac{M}{L T^2}$$

The bracketed symbols represent, respectively, electric displacement (measured by surface-density); electromotive force at a point; magnetic induction; magnetic force; current electric intensity at a point; vector potential of electric current.

η. Electrochemical and electromagnetic energies may be compared with thermal, photodynamic and other energies, through the proportion

$$\chi : \mu :: M_0 t_a^2 \times M_0 v_3^2 : m_3 t_n^2 \times m_3 V_0^2$$

I designate Weber's units of electrochemical and electromagnetic force by χ and μ, respectively; t_a is the time of acquiring orbital velocity, or incipient associative energy, at Laplace's limit of equal velocities of rotation and revolution; t_n is the time of acquiring nucleal nascent or dissociative velocity.

$$t_a : t_n :: 1 : \pi$$

θ. Total magnetic force, φ_0, can be compared with the reactions of terrestrial magnetic force, φ_3, by the proportion

$$M_0^2 : \pi^4 m_3^2 :: \varphi_0 : \varphi_3$$

The reactions of orbital tendency are $t_a M_0^{\frac{1}{2}}$, $t_n m_3^{\frac{1}{2}}$, respectively; centripetal acceleration varying as the fourth power of orbital velocity, we have the ratio, $M_0^2 : \pi^4 m_3^2$.

(Contributions from the University of Pennsylvania, No. 16.)

On Alaskaite, a new member from the series of Bismuth Sulphosalts. By Professor George A. König.

(Read before the American Philosophical Society, June 17, 1881.)

Mode of occurrence. The high mountain mass of south-western Colorado culminates in Mt. Sneffels at an altitude of 14,156 feet. But this great height does not impress itself upon the observer since the deepest valleys are still 7000 feet above the sea. The geological structure of these mountains is very simple as a whole; but the energetic action of the forces of erosion, has produced a very rich and picturesquely carved topography, there being no table mountains, but only steep peaks and sharply indented crests. Mineral veins in clearly defined outcrops intersect these moun-

tains in astonishing abundance. They are easily traced on the bald slopes, which rise from one to three thousand feet above timber line. The geology, as already stated, is quite simple. Orthoclastic eruptive rocks—Quartz-porphyry, Porphyrite and Trachyte—overlie granitoid metamorphic schists (chiefly gneiss) as an enormous sheet one mile thick. Only towards the West we find palæozoic rocks, sandstones, limestone and coal beds, lying between the crystalline top and bottom rocks, not exceeding probably 500 feet in thickness. All the peaks and crests visited by me were found to be made up of porphyritic rocks, schists and sedimentary rock being only found in the deep cañons. The silver bearing veins I found to be confined to the eruptive rocks with but few exceptions, *i. e.*, the "mineral farm," near Ouray in Silurian limestone; the "black Wonder mine" and some other veins in Burough's Park, which lie in granitoid gneiss.

One of the most interesting sections of this wonderful region is *Poughkeepsie Gulch*, one of the head forks of the Uncompaghre river. Here we find numerous veins in a bleak wilderness directly under the pass which leads from the Uncompaghre valley over into the Cement creek, one of the feeders of the Animas river. Very prominent among its neighbors is the *Alaska* vein which was opened by two adits at the time of my visit last August. The vein is well defined, striking nearly north and south, with almost vertical dip. The breast of the lower adit showed beautiful ore. Nests of gray copper and Alaskaite in a gangue of quartz and barite. Even with candle light the gray copper and Alaskaite (Bismuth silver ore so called here) are distinguishable, and are separated by handpicking into first class, and second class ore. I found some difficulty in procuring specimens, as the foreman had orders not to allow specimens being taken away.

Physical properties of Alaskaite. The specimens consist of a more or less intimate mixture of the new mineral with barite and chalcopyrite, and sometimes a little quartz. Neither blende nor galenite could be detected. The small quantity of antimony shown by the analysis might be due to the presence in the mixture of some gray copper or other Stibiosulphosalts, or may be replacing bismuth in the Alaskaite. But could in no way interfere with the correct definition of the new mineral, as will be seen later. The complete decomposition with hydrochloric acid speaks quite in favor of the latter view.

The structure of Alaskaite is small foliated, some smooth cleavage planes may be observed here and there. Its color is whitish lead-gray, approaching bismuthinite; its lustre strongly metallic; opaque. Color of the fine powder is bluish-gray. The structure forbids a determination of hardness, but the mineral is mild in the mortar, and easily friable.

The *specific gravity* was determined with the fine powder used for the Analyses C and D, and found to be 6.878 by the following calculation:

Let $S = 1^g.3165 = A + B + C$ (Alaskaite + barite + chalcopyrite)

then we have $p = \frac{A}{\delta} = \frac{S-B-C}{\Delta-\delta_1-\delta_2}$

The analysis gives B = 0.15; S = 0.1975; C = 0.228; S = 0.0301

$$\delta_1 = \frac{0.1975}{4.486} = 0.644; \quad \delta_2 = \frac{0.0301}{4.2} = 0.0072$$

$\Delta = 0.2095$ by experiment.

hence S—B—C = A = 1.0889; $\delta = \Delta - \delta_1 - \delta_2 = 0.1583$

and $p = \frac{1.0889}{0.1583} = 6.878.$

Blowpipe reactions. The mineral decrepitates in the closed tube, similarly to the majority of compounds belonging to this group, it melts then at red heat without the formation of a sublimate. Heated with the O. Fl. on charcoal it yields a deep yellow incrustation with a white non volatile fringe, coloring the seam of the flame faintly azure blue (lead). Upon continued blowing a crimson to peach blossom red zone appears between the yellow and white incrustation (silver). The residue gives the reactions of copper and iron with borax and microcosmic salt, and after cupellation with lead, a considerable silver button. With potassium iodide and sulphur an intense brick red coating is obtained (bismuth). In the open tube sulphurous anhydrite (sulphur) and a minute white sublimate (antimony) are given off, while a yellow residue is produced. Cold concentrated hydrochloric acid acts very slowly upon the finely pulverized mineral, but the heated acid decomposes it completely and rapidly, leaving flocculent silver chloride.

Analyses. So intimate is the mixture of Alaskaite and chalcopyrite, that a complete mechanical separation was not feasible. Now it is quite possible to remove the Alaskaite by HCl from the chalcopyrite and barite, but the quantity of copper-iron-bisulfide is always so small (see analyses) that if the iron be taken as representing chalcopyrite, no appreciable error will be committed. A small quantity of the mineral was picked out carefully, leaving only traces of chalcopyrite, for a preliminary analysis. 250 mg. gave: Bi_2O_3 = 160.0 mgr; $PbSO_4$ = 38.0 mgr. Ag Cl = 23.5 mgr; CuO = 7.0 mgr; birite = 8.3 mgr. The substance minus barite was 141.7 mg. Calculated upon this number we have:

Bi_2S_3 = 73.02; PbS = 12.40; Ag_2S = 9.06; Cu_2S = 6.20 corresponding very closely to the ratio $(RS)_{20} + (Bi_2S_3)_{21}$ that is probably as 1 : 1. A quantitative blowpipe assay gave 7.5 p. c. Ag, or minus barite, 8.90 Ag_2S.

With less carefully picked material the following 2 analyses were made, A and B, the determinations of Bi and Pb in A being lost:

	A (1g.5000)	B (1g.0000)
Insoluble	0.2382	0.1551
AgCl	0.1337	0.0945
CuO	0.0710	0.0462
Fe_2O_3	0.0220	0.0168
ZnO	0.0040	0.0030
BiClO	——	0.4945
Bi_2O_3	——	0.0385
$PbSO_4$	——	0.1480
$BaSO_4$	——	0.9683

Deducting the insoluble (barite) we obtain per cent.

	A	B	Mean.
Bi =	——	51.49	51.49
Pb =	——	12.02	12.02
Ag =	7.97	8.19	8.08
Cu =	4.49	4.37	4.43
Fe =	1.22	1.40	1.31
Zn =	0.24	0.29	0.26
S =	——	17.20	17.20
			94.79

Deducting again Fe = 1.31 ; Cu = 1.48 ; S = 1.48 as chalcopyrite, we obtain for Alaskaite

Bi	= 51.49	:	208	=	0.2475	
Pb	= 12.02	:	207	=	0.0585	0.1236
Ag	= 8.08	:	216	=	0.0374	
Cu	= 3.00	:	126.4	=	0.0237	
Zn	= 0.26	:	65	=	0.0040	
S	= 15.72	:	32	=	0.4912	

that is 0.1236 R : 0.2475 Bi : 0.4912 S = 1 : 2.002 : 3.974

Notwithstanding the simple ratio, this result cannot be utilized to base definite conclusions thereon, since there is an unaccounted loss of nearly 5 per cent. in the analyses. From the same specimen material was now taken off another corner, and 2 analyses made as follows :

	C (1^{g}.000)	D (1^{g}.0000)	Mean.
Bi =	47.27	46.47	46.87
Sb =	0.51	——	0.51
Pb =	——	9.70	9.70
Ag =	7.19	7.01	7.10
Cu =	3.54	3.75	3.64
Fe =	0.70	0.70	0.70
Zn =	0.56	0.72	0.64
S =	15.85	——	15.85
Insoluble =	14.90	15.10	15.00
			100.01

Taking the iron again as coming from chalcopyrite we deduct 0.79 Cu and 0.79 S, leaving

Bi	= 46.87	:	208	=	0.2253	0.2294
Sb	= 0.51	:	122	=	0.0041	
Pb	= 9.70	:	207.2	=	0.0468	0.1133
Ag	= 7.19	:	216	=	0.0342	
Cu	= 2.85	:	126.4	=	0.0225	
Zn	= 0.64	:	65	=	0.0093	
S	= 15.07	:	32	=	0.4709	0.4709
$(Fe_1Cu)S_2$ =	2.28					
Barite =	15.00					

hence R : Bi : S = 1 : 2.020 : 4.14

The composition of Alaskaite is therefore in 100 parts

Bi	=	56.97
Sb	=	0.62
Pb	=	11.79
Ag	=	8.74
Cu	=	3.46
Zn	=	0.79
S	=	17.63
		100.00

This latter result must be taken as establishing the nature of Alaskaite, beyond reasonable doubt.

But on examining some other specimens qualitatively, which appeared to be identical in physical characters with the preceding one, I could not at first produce the crimson silver coating. Suspecting an essential difference I made upon the same powder three analyses the mean of which (closely agreeing) is as follows :

Bi	= 51.35	Bi	= 51.35	: 208	=		0.2468
Pb	= 17.51	Pb	= 17.51	: 207.2	= 0.0845	}	
Ag	= 3.00	Ag	= 3.00	: 216	= 0.0138	}	0.1308
Cu	= 5.38	Cu	= 3.74	: 126.4	= 0.0295	}	
Fe	= 1.43	Zn	= 0.20	: 65	= 0.0030	}	
Zn	= 0.20	S	= 16.21	: 32	=		0.5080
S	= 17.85	$(Cu\,Fe)S_2$	= 4.71				
Insoluble	= 2.83	Barite	= 2.83				
	99.55						

$$R : Bi : S = 1 : 1.887 : 3.883 = 1 : 2 : 4$$

This then is the same mineral, except that the greater part of the silver is replaced by lead.

We have then in Alaskaite a complete type of the sulphosalts of the first order, according to Rammelsberg's symbol :

$$(\dot{R}_2\,\ddot{R})\,S + r^2\,S^3$$

to wit

$$(\ddot{P}b_1\,\ddot{Z}n_1\,Ag_2\,Cu_2)\,S + (Bi^1\,Sb)^2\,S^3$$

Of this type several members are known, but the copper bismuth glance from Schwarzenberg, and perhaps Domeyko's ore from Copiapo contain bismuth exclusively on the negative side.

The crystallographic symmetry of all the members of this type is probably *orthorhombic*.

A specimen from the Alaska mine, which had been sent to me as bismuth silver-ore, being composed of quartz, barite, chalcopyrite and what

appeared to be gray copper was pulverized as a whole, and analyzed with the following result:

		Calculated			
Sb	= 10.10	Sb_2S_3	= 13.68 : 340 = 0.0402	}	0.0530
Bi	= 5.05	Bi_2S_3	= 6.59 : 512 = 0.0128	}	
Cu	= 14.97	Cu_2S	= 17.01 : 126 = 0.1076	}	0.1673
Pb	= 3.84	PbS	= 4.04 : 239 = 0.0169	}	
Ag	= 0.70	ZnS	= 3.84 : 97 = 0.0396	}	
Zn	= 2.56	Ag_2S	= 0.80 : 248 = 0.0032	}	
Fe	= 1.23	$(Cu_1\ Fe)\ S_2$	= 4.03		
S	= 11.53	Quartz, etc.	= 48.55		
Insoluble	= 48.55				
	98.55				

If the gray substance be considered homogeneous then its molecular ratio will be

$$RS : r^2S^3 = 3.1 : 1$$

But gray copper has the ratio of 4 : 1. If the bismuth sulphide be now eliminated with the corresponding positive sulphide in the Alaskaite ratio of 1 : 1, then we get for the ratio of the rest

$$RS : Sb_2S_3 = 3.86 : 1$$

that is nearly the gray copper ratio.

It is made even more probable that such a mixture be here in existence, by qualitative tests upon a large specimen, weighing several kilograms of the massive gray mineral. These tests indicated very varying percentages, by the intensity of bismuth reaction from different points of the piece.

It is a matter of remark from a genetic point of view, that we find in this vein nests of Alaskaite quite free from the gray copper, while the latter seems to be mixed generally with the former in other places whenever it predominates.

The Auriferous Gravels of North Carolina. By H. M. Chance, M.D.

(Read before the American Philosophical Society, July 15, 1881.)

The belt of auriferous gravel stretching in an almost unbroken line from the New England States to Alabama, is broadest in North Carolina, where it has also been more productive in the past, and promises greater results in the future than in any other State through which it passes.

Yet notwithstanding the flattering prospects apparently presented by these gold fields, the companies organized to work them have rarely at-

tained practical success even for a short period; they have, in fact, almost without exception, failed to pay dividends, and their stock is now a drug in the market.

But a period of excitement has again been inaugurated, capitalists are again investing in mines long since abandoned as unremunerative, and old Californian miners are leaving the West for the more glittering prospects of the East, where they say the gravel is much richer.

While making an examination of mineral lands in Central and Western North Carolina, I recently noted a series of facts that may explain in general why these fields have not been remuneratively productive in late years, although the gravel does contain a larger average amount of gold per cubic yard than many Western placers now profitably worked.

When one inquires why the workings are not financially successful, he is immediately met with the statement that the mines paid handsomely prior to the California excitement in '49, when the Western gold fever caused a suspension of operations; that the civil war caused a second stoppage; and that there are many reasons why they have not been systematically worked since the war.

These statements are honestly made, and are to some extent true; but from 1855 to 1860, several companies were working, and with very discouraging results, and since the war several mining operations have been commenced, but discontinued—because they were not remunerative. It cannot be claimed that these operations were unsuccessful because they were not prosecuted for a sufficiently long period, for in placer workings, the results, if any, are quickly attained.

The early workings, prior to the California discoveries, were undoubtedly remunerative. They were confined principally to the gravel deposits found along the smaller streams, and their tributaries, notably on the First and Second Broad rivers, and on Silver and Muddy creeks in Rutherford, Burke and McDowell counties. The gravel was worked by panning, by the rocker and "*long-tom*," and it is also claimed at one place at least, by sluicing with a head of water.*

A brief review of the geological peculiarities of the region will explain the great difference between these old workings, and the gravels now being washed.

In the Geology of North Carolina by Prof. W. C. Kerr, page 156, the gold gravels are referred to the Champlain period, and are described as beds of *till* or decomposed rock (*initial drift*), sometimes in place, sometimes several hundred feet lower on the hillside than the rocks from which they were derived by disintegration.

The truth of this statement is apparent to every careful observer, and this view is now generally accepted among those practically engaged in working these deposits.

The gold seems to be irregularly distributed through the so-called "slates" (mica schist, micaceous gneiss, hornblende, schist, etc.), either in

*The first use of this method is generally credited to California.

thin quartz veins or disseminated through the mass. As erosion progresses, the decomposed schist is converted into gravel, the lighter and finer particles of clay, mica, etc., being easily washed out by the percolation of rain water, leaving the heavier minerals and the larger quartz fragments behind. Thus an essentially concentrating process is and has been constantly progressive since the Glacial period, and the gravel now found lying as a surface covering from one to thirty feet thick may, and probably does, represent several times its thickness of rock, the coarser and heavier fragments of which alone remain.

The thickness of the gravel in the South Mountain region probably averages from six to nine feet, but I consider that this represents the remains of at least twenty or thirty feet of rock. On this basis the gravel should contain more than three times as much gold as an equal bulk of the mother rock—it is, in fact, found to be much richer.

The streams draining this region have carried away millions of cubic yards of this gravel. The old river bed workings in California have shown that all streams act as natural sluices, separating and concentrating the gold and heavier minerals from rocks of less specific gravity, and this action has undoubtedly been operative in these North Carolina streams. The gravel washed into the smaller stream beds dropped its coarser gold before being carried out into the main water courses, and we consequently find that the rich washings were nearly all found in the beds of the small creeks and their tributaries.

These were thoroughly worked over during the early mining excitement, prior to the exodus in '49, yielding to hand panning and to work with the rocker and long-tom, from two to ten dollars a day. They have since been reworked; at some places the same gravel has been washed three or four times. It was very rich, necessarily so, for working a stream down to bed-rock* is like cleaning up a sluice—it contained the gold dropped from millions of cubic yards of gravel, the accumulation (*concentrates*) of thousands of years.

There are a few localities where these stream gravels are as yet undisturbed. They will yield good returns, but their area is very small.

The vast bulk of gravel now remaining to be worked is hill gravel; its thickness will not exceed an average of nine feet, and it is of varying degrees of richness.

On some tracts gravel may be found yielding from one to ten colors to the pan, and work done with a rocker may show from five grains to a pennyweight to the cubic yard, a most flattening prospect to the Western hydraulic miner; but such results are rare. I am inclined to think that five or six grains to the cubic yard is as much as can be expected from an average run of fair gravel.

The important question, now being solved in a practical way on the

*The bed-rock was usually not more than two or three feet beneath water level.

ground, is: Can these deposits be profitably worked by hydraulic mining? The question may be answered both in the affirmative and in the negative.

At a few places where the gravel is both rich and thick—ten feet or more—and water can be obtained in sufficient quantity at moderate cost, hydraulic mining may be successful—but

1. A large working area is necessary.
2. The closest economy must be exercised, and
3. A relatively small amount of capital invested.

A large area is necessary, because the deposit is not thick; assuming an average thickness of four yards, one acre would yield but 19,360 cubic yards of gravel, and one-fourth of this being top gravel and soil might contain very little gold, as the gold is often concentrated in the lower layers, sometimes in a "pay-streak," near the bed-rock. This "pay-streak" is at times quite thin—one, two or three feet thick, but the gold is more usually disseminated through the mass.

The difference between the cost of working these thin deposits, and the enormously thick gravels of California and Oregon will be readily appreciated by the hydraulic engineer, and to this difference is due the fact that although these gravels are much richer than many Western deposits successfully worked, the prospect of remunerative mining in this region is much less.

In some localities the cost of bringing water will be very great; ditches ten or twelve miles long being necessary. At the Sam Christian mine, on the Yadkin river, arrangements are even being made to *pump* the water!

It will also be difficult to obtain sufficient fall to carry off the tailings, for some of the richest of the hill gravels has been found in comparatively low ground, where much of the material must be moved by hand. I noted one mine working under just such conditions, that was yielding as well as the best can be expected to average. The gravel was about four yards thick, the gold occurring principally in a pay-streak near the bed-rock. The lowermost four or five feet was moved by hand, some pick work being required.

The cost for labor was about 64 cents per superficial square yard, and the yield averaged over a considerable area one pennyweight—85 cents. Labor 75 cents per day. This shows a profit of 21 cents per superficial square yard or 5.25 cents per cubic yard; but these figures do not include the cost of superintendence, mercury, wear and tear, etc. When these items are included, it can easily be seen that the operations were being carried on at an actual loss, for not more than one hundred yards were washed per diem, and the profit on this would not pay the expenses of management.

A trial of General Strong's injector dredging machine* is now being made on the gravels in the bed of Silver creek. It seems better adapted to working on river bottoms than on these small South Mountain streams.

* Described by Dr. R. W. Raymond, in Vol. viii, Transactions of the American Institute of Mining Engineers.

I have reason to think from what I have seen, that there are comparatively few localities where these North Carolina hill gravels can be successfully worked at present; that in any event the returns—considering the risk—will be small; that no "bonanza" need be expected, though local deposits of very rich gravel will undoubtedly be found; and that no operations can be successful unless the *strictest economy* is observed in all the details both of *management* and *working*.

Stated Meeting, July 15, 1881.

Present, 4 members.

Vice-President, Dr. LeConte, in the Chair.

A letter acknowledging the receipt of certificate of membership was received from Ast. Roy. G. B. Airy, dated Royal Observatory, Greenwich, June 18, 1881.

Acknowledgments of the receipt of Proceedings were received from the Smithsonian Institution (boxes of 302 addresses for distribution; and 108); the Prag Observatory (104, 105, 106; List); R. Danish S. S. (105, 106; List); Vermont Historical Society (107); Mus. C. Z. Harvard Collection (108); A. Agassiz (108); T. P. James (108); New Bedford Public Library (108); United States Military Academy (108); Poughkeepsie S. N. S. (108); J. J. Stevenson (108); Buffalo S. N. S. (108); F. A. March, Easton, Pa. (108); Chicago Historical Society (108); and State Historical Society, Wisconsin (108).

Donations for the Library were received from the New Zealand Institute; the Danish Society of Sciences; Accademia dei Lincei; Revista Euskara; Society C. Geog., Bordeaux; Geographical Society, Paris; Mus. N. H., Paris; Royal Belgian Academy; Royal Astronomical Society and Meteor. Com. London; Boston N. H. S.; American Oriental Society; Har-

vard University; New Jersey Historical Society; Franklin Institute, Journal of Pharmacy, American Journal of Medical Science, Medical News and Abstract, Pennsylvania Magazine H. and B., Philadelphia Library Company, Alumni Association, University of Pennsylvania; J. W. Powell, Washington; Jed. Hotchkiss, Staunton; California Academy of Sciences, and Mariano Barcena, of Mexico.

The death of Mr. W. E. Dubois, at Philadelphia, July 14, 1881, aged 70, was announced by Dr. LeConte with appropriate remarks.

The death of Dr. Geo. Rolleston, at Oxford, England, June 17, 1881, aged 56, was announced by the Secretary.

The following communications were presented:

"On the Auriferous Gravels of North Carolina, by H. M. Chance, M. D." (See page 477 above.)

"The Brain of the Cat, *Felis domestica*. 1. Preliminary account of the Gross Anatomy. With four plates. By Burt G. Wilder, M. D. Professor of Anatomy, etc. in Cornell University, and of Physiology in the Medical School of Maine."

"The Vague Nerve in the Domestic Cat, *Felis domestica*. With three plates, by T. B. Stowell."

Balloting for new members was postponed to the 21st of October next.

Pending nominations 934 to 940 were read, and the meeting was adjourned.

Stated Meeting, September 17, 1881.

Present, 3 members.

Prof. COPE, in the Chair; Dr. HORN; Mr. LESLEY.

Letters of acknowledgment were read from the London Zoölogical Society (XV ii; Cat. III; 97—106); Leipsig Astronomical Society (106, 107); Teyler Fondation (107, 108); Holland Society (XV iii, 107, 108); Brown University (108); and Yale College (108).

Letters requesting numbers of Proceedings for the completion of sets were received from Prof. W. D. Whitney and Dr. Jacob M. Dacosta.

Donations were reported from the Academies at St. Petersburg, Berlin, Bruxelles, Rome and New York; from the Observatories at San Fernando, Greenwich and Cape Town; from the Society at Bonn; the Geographical Societies at Bordeaux and Paris; the London Astronomical and Antiquarian Societies; from Prof. Steenstrup, Dr. Schäffler, Herr Tischner, Herr Freytag, M. Renevier and Prof. W. Huggins; the Revista Euskara, Revue Politique, Chemists' Journal, and London Nature; the Annales des Mines; the Cobden Club; the Victoria Institute; Essex Institute; Boston S. N. H.; R. C. Winthrop, Dr. S. A. Green; Yale College; American Journal of Science; New York Academy; American Chemical Society; Metropolitan Museum of Art; New York Mercantile Library Association; Princeton Museum; Franklin Institute; College of Physicians; Journal of Pharmacy; Medical News; C. A. Ashburner; P. W. Sheafer; the National Museum; U. S. Bureau of Education; Buffalo N. H. S.; American Antiquarian, and J. Hotchkiss, of Virginia.

Prof. Cope communicated a paper entitled, "On some Mammalia of the Lowest Eocene beds of New Mexico."

Pending nominations Nos. 934 to 942, and new nominations Nos. 943, 944, 945, were read.

There being no quorum present, several items of business were postponed for consideration at the next meeting.

PROC. AMER. PHILOS. SOC. XIX. 109. 3I. PRINTED OCT. 21, 1881.

On some Mammalia of the Lowest Eocene beds of New Mexico. By E. D. Cope.

(*Read before the American Philosophical Society, Sept. 17, 1881.*)

MESONYX NAVAJOVIUS, sp. nov. Smaller than the two known species, and with the crowns of the molars more compressed and the blades of the heels of the inferior series more acute. Molars seven, the first one-rooted. Last molar with a cutting heel like the others, and with the penultimate, with a rudimental anterior inner cusp. All the molars with an anterior basal tubercle except the first, second and third. No basal cingula. Principal cusp elevated and compressed, as in the premolars of *Oxyæna*. Enamel minutely rugose. Mandibular rami and inferior canine teeth compressed, the angle of the latter not inflected. Length of inferior molar series M. .078 ; do. of premolar series .046 ; fourth premolar, length of base .010 ; elevation of cusp .008 ; second true molar, length .012, elevation .010 ; width of heel .005 ; depth of ramus at .020 ; diameter of base of crown of canine, vertical .009.

PERIPTYCHUS CARINIDENS, gen. et. sp. nov. Creodontium. *Char. Gen.* No distinct sectorial teeth, the first and second true inferior molars similar. They support a principal median cusp, a broad heel and a prominent anterior cingulum. The heel is more or less divided into tubercles ; the anterior cingulum is on the inner side, and represents the anterior cusp of a sectorial tooth. On the inner side of the principal cusp a cingulum rises, forming a flat internal tubercle. Last molar not smaller than the others ; premolars unknown.

This genus belongs to the *Amblyctonidæ* with *Amblyctonus* and *Palæonyctis*. It differs from both in the rudimental character of the anterior cusp, and from the former, in the presence of the internal tubercle. In *Mesonyx* the heel has a median cutting edge. *Char. Specif.* Parts of both mandibular rami and the shaft of a humerus represent this species. They indicate an animal of the size of the red fox, but much more robust. The mandibular ramus is rather shallow and thick, and the molars are not large. The heel of the penultimate supports three tubercles, of which the external is the largest. The anterior cingulum supports a small cusp, and then rises to the internal tubercle, which is compressed. The sides of all the cusps are marked with distinct, well separated, vertical ridges. Each extremity of the internal cusp is connected with the principal cusp by a ridge. The first true molar has fewer cusps. Those of the heel are scarcely distinct, and form a border which rises prominently into the flat internal tubercle, which forms a narrow longitudinal blade. The anterior cingulum has no cusp and does not rise into the inner tubercle. The principal cusp has a strong entering groove next the inner tubercle. Length of crown first molar .0115 ; width of do. .006 ; elevation of do. .006. Length of second molar .011 ; width of do. .007 ; elevation of do. .0065. Depth of ramus at do. .020. The species is a good deal smaller than the *Amblyctonus sinosus*.

TRIISODON QUIVIRENSIS, gen. et sp. nov. *Char. gen.* Derived from the lower jaw. Probably only three premolars. True molars alike, consisting of three anterior cusps and a heel. The cusps are relatively small and the heel large. Of the former the internal is much smaller than the external, and the anterior is rudimental, being merely a projection of the cingulum. The cutting edges of the large external cusp are obtuse. The heel is basin-shaped, and its posterior border is divided into tubercles, of which the external is a large cusp. The fourth premolar has no anterior inner tubercle, so that the anterior part of the crown consists of a compressed cutting cusp. The heel has two well-developed posterior cusps. The third premolar has a similar principal trenchant cusp, but a smaller heel. Canines large.

This genus differs from *Herpetotherium* and *Ictops* in the simplicity of its fourth inferior premolar, and from *Stypolophus* and *Deltatherium* in the rudimental character of the accessory anterior cusps of the true molars, as well as in the three premolars. The rudimental anterior cusp of the true molars, with the three similar true molars, separates it from *Palæonyctis*, and the presence of a conic inner cusp of the same indicates it as different from *Amblyctonus* and *Periptychus*. It is not possible to state whether *Triisodon* must be placed in the *Amblyctonidæ* or not, on account of the absence of the superior molar teeth.

This specimen of the type species of this genus is instructive as showing the succession of premolar teeth. Both the third and fourth premolars have temporary predecessors. The predecessor of the fourth premolar differs much from it in form, and is essentially identical in all respects with the true permanent molars. The crown of the predecessor of the third premolar is wanting, the roots only remaining in the jaw.

The permanent third premolar was protruded before the permanent fourth. Which temporary tooth of *Triisodon* is homologous with the single one of the *Marsupialia* pointed out by Professor Flower?* As the additional permanent teeth of the placental *Mammalia* must have appeared later in time than the one already found in the implacentals, they must be those later protruded; hence the fourth tooth in the jaw of *Triisodon* must be regarded as homologous with the fourth premolar of a placental, which is the last of that series to appear. If this be true, the tooth which follows the shed tooth of the Marsupials is not the fourth premolar, as supposed by Professor Flower, but the third premolar. This view is confirmed by the fact that the milk tooth displaced by the fourth tooth in *Triisodon* resembles in all respects the true molars, just as the permanent tooth occupying the same position does in *Didelphys* and some extinct eocene genera. This goes to show that this tooth, permanent in marsupials, is temporary in placentals, and that, in spite of its form in the former group, it is the fourth premolar, and not the first true molar, as supposed by Professor Flower. Thus the posterior milk-molar of diphyodonts is a permanent tooth in the *Marsupialia*.

* Transactions of the Royal Society, 1867, p. 631.

This observation confirms my conclusion that the *Credonta* form a group intermediate between the *Marsupialia* and *Carnivora*. I may add that in *Triisodon* the inferior border of the lower jaw is not inflected posteriorly.

Char. specif.—Size about that of the wolf. Inferior canine directed upwards, its section nearly elliptic; a faint posterior, no anterior cutting edge. Fourth premolar rather large, with an anterior basal cingulum which is angulate upwards, and is not continued on the inner side of the crown. Cusps of the heel each sending a ridge forwards, the internal lower, obtuse and descending to base of inner side of large cusp; the external larger, with an acute anterior cutting edge continuous with the cutting edge of the large cusp. True molars with an external, but no internal basal cingulum. Border of heel with one large and three smaller tubercles, the former with, the latter without, anterior cutting edge. Enamel of all the teeth nearly smooth. All the cusps are rather obtuse. *Measurements.*—Length of inferior molar series: M. .080; long diameter of base of canine .013; length of true molar series .044; length of base of Prem. IV. .016; elevation of crown of do. .014; length of base of M. II. .016; width of do. in front .011; elevation of do., .014. The measurements of the jaw are not given, as the animal is not adult, the last molar not being yet protruded.

From the lowest Eocene beds of New Mexico.

DELTATHERIUM FUNDAMINIS, gen. et sp. nov. *Char. Gen.* Fam. *Leptictidæ*, agreeing with *Ictops* and *Mesodectes* in possessing an internal tubercle of the third superior premolar, but differing from both in having but one external cusp of the fourth superior premolar. *Char. Specif.* Represented by the dentition of both maxillary bones minus the canines. The second premolar is convex on the inner face. The base of the third is a nearly equilateral triangle. The bases of the true molars are triangles, with the bases external. The internal angle supports an acute cusp, and has a posterior basal cingulum, which is very strong in the last three molars. The two external cusps of the first and second molars are situated well within the base, which is folded into a strong cingulum. This cingulum develops strong anterior and posterior angles. This is the largest species of the family yet discovered. Extent of series of last six molars, M. .045; of true molars .026; diameters of fourth premolar, anteroposterior .0074; transverse .0076; do. of second true molar, anteroposterior .0087; transverse .0100. This species was a fourth larger than the common opossum, and very much resembles it in dental characters.

CONORYCTES COMMA, gen. et sp. nov. *Char. Gen.* Allied to *Mesonyx*. Inferior canines not rodent-like, with conic crowns. Molars 3—3, the first one-rooted, the second two-rooted, the third with an anterior conic cusp and a posterior grinding heel. True molars consisting of two lobes, of subcylindric section, separated by deep vertical grooves. Enamel developed on internal and external faces of crowns. *Char. Specif.* Founded on a mandibular ramus which lacks the last molar, and has the crowns of the others worn. The external faces of the molars are much more ex-

posed than the internal, and are somewhat contracted inwards. In the unworn crown there is a distinct anterior inner cusp, which is soon confounded on attrition. The heel of the last premolar has a crescentic section, the internal horn the narrower. The anterior lobe is a robust cone. The base of the second and third premolar is oblique to the axis of the ramus outwards and forwards. It is possible that there is a minute first premolar filling the short space between the second and the canine. No cingula; enamel obscurely plicate, ramus robust. Length of molars minus the last .0465; length of base of first true molar .010; width of do. .009; elevation of crown do. .0055; length of base of fourth premolar .011; width of do. .008; elevation of crown of do. .0065. Anteroposterior diameter of base of crown of canine .010. Depth of ramus at first true molar .023; width of do. at do. .013. This genus differs from *Esthonyx* in the form of the fourth premolar. In the latter the anterior lobe is compressed and trenchant. The species is larger than any of that genus, and nearly equal to the *Ectoganus gliriformis*.

CATATHLÆUS RHABDODON, gen. et sp. nov. *Char. Gen.* With this genus I commence descriptions of several genera with bunodont dentition, which has some resemblance to that of some of the hogs. The one above named, with *Mioclænus*, remind one of *Tetraconodon* Falc. and Lydd., in the enlarged proportions of their premolar teeth. I compare the genera as follows, introducing a probably perissodactyle form (*Protogonia*) for comparison:

I. Third and fourth superior premolars one or two lobed externally, and with internal lobes.

a. Superior premolars with two external lobes; inferior fourth with two median cusps.

Intermediate tubercles; premolars not enlarged.....*Phenacodus.*

aa. Superior premolars enlarged, generally with one external cusp.

β. A posterior internal cusp of superior molars;

Intermediate tubercles present; last inferior premolar with inner cusp; *Catathlæus.*

Intermediate tubercles wanting, replaced by branches of an internal V; no cusp on inner side of last inferior premolar.....*Anisonchus.*

Intermediate tubercle present, connected with anterior inner by ridges; inferior molars with Vs.....*Protogonia.*

ββ. No posterier inner cusp of superior molars.

Intermediate tubercles present; no inner lobe of last inferior premolar *Mioclænus.*

II. Superior premolars 1, 2 and 3 without inner lobe; third with three external lobes (Pictet).

Premolars compressed.....*Dichobune.*

In the genus *Catathlæus* the development of the premolars is remarkable while the true molars are relatively small. The last three superior premolars have an elevated internal crescentic cingulum homologous with

the inner lobe of the fourth superior premolar of the ruminants. The general character of the true molars is that of *Phenacodus*. Parts of two or three individuals of this species have come into my possession, one of which includes nearly all of the molar dentition of both jaws. The external cusp of the superior premolars is compressed conic, and the internal cingulum extends to its *anterior* base in the second, third, and fourth. The crown of the last true molar is about as long as wide, while that of the first is wider than long. Each supports seven cusps; two subconic external, and one large median internal, which is connected by ridges with a small anterior and posterior median. Then there are a small anterior and posterior internal, making three internal. The internal crest is distinct from the principal cusp in the inferior premolars III and IV, but unites with it in the II; it supports on the IV an anterior, a median and a posterior cusp, the latter forming part of the rather narrow heel. The true molars I and II have seven tubercles, the four principal ones, and three smaller, one anterior, one posterior, and one median. On the third the posterior forms a large heel. All of the molars, but especially the premolars, have the enamel thrown into sharp vertical parallel folds, in a manner I have not seen in any other mammal. Length of six superior molars .067; length of three true molars .029; length of base of third premolar .012; width of do. .012; width of base of first true molar .010; do. of third true molar .009; length of do. .010. Length base fourth inferior premolar .012; width do. .010; length of third true molar .0115; width of do. .009. The teeth indicate an animal of the size of the peccary.

ANISONCHUS SECTORIUS, gen. et sp. nov. *Char Gen.* This is derived from the superior P-m. IV and M. I and II, and from all the inferior molars of three individuals. The superior teeth are accompanied by a ramus mandibuli, which contains alveoli of all the inferior molars, and the crowns of the P-m. IV and M. II. The leading characters have been given above. The inner posterior lobe is more prominent in this genus than in any of the others, and has a V-shaped apex. It projects further inwards than the anterior inner lobe. It is represented by a mere tubercle of the cingulum in *Mioclænus*. In the lower jaw the last premolar is quite simple, consisting of a principal cusp, and a non-cutting heel. The second true molar has intermediate anterior and posterior cusps. The genus differs from *Pantolestes* in the more numerous tubercles of the molars, and in the fact that the anterior inner tubercle of the true molars is not double. It may, however, be allied to that genus.

Char. Specif. The fourth superior premolar covers a larger base than either of the true molars The external cusp has a base extended anteroposteriorly, but the apex is conical, and there are no basal tubercles. The inner cusp has a crescentic base as in *Catathlæus*, but the apex is narrowed and compressed conic. The external tubercles of the true molars are subconic, and do not develop any external ridges. They are connected by the crescentic slightly angular crest, whose apex forms the inner ante-

rior boundary of the crown. This crest is not divided into parts homologous with the intermediate tubercles. The crowns of the M. I and II are surrounded by a basal cingulum, which in the M. I develops a tubercle at the anterior external angle. No internal or external cingulum on P-m. IV. Enamel nearly smooth.

The ramus of the mandible is rather slender anteriorly. The P-m. IV is robust, and the cusp is behind the middle of the base of the crown. The heel is short and narrow, and has a raised border, connected with the base of the main cusp. The cusps of the second true molar are elevated and conic, the anterior external the highest, the others subequal. The base of the posterior pair is a little narrower than that of the anterior pair. There is no central tubercle as in *Catathlæus rhabdodon*, and no basal cingulum on either tooth.

Measurements.		M.
Length of three superior molars		.0160
Diameters superior P-m. IV	anteroposterior	.0055
	transverse	.0070
Diameters superior M. I	anteroposterior	.0052
	transverse	.0060
Length of inferior molar series		.0610
" " " true molar series		.0160
Diameters inferior P-m. IV	anteroposterior	.0060
	transverse	.0040
Diameters inferior M. II	anteroposterior	.0050
	transverse	.0040
Depth ramus at M. II		.0090

A number of minor points will distinguish this species from those included among the *Mesodonta*, and especially those of *Pantolestes*, which it most resembles. The molar teeth are narrower behind, and the fourth premolar is larger. It is *Mioclænus sectorius*, American Naturalist, October, 1881, p. 831.

MIOCLÆNUS TURGIDUS, gen. et sp. nov. This genus differs from *Catathlæus* in the structure of the inferior premolars, which are without internal crest or cusp. The inner lobe of the superior premolars is less developed than that genus. In the present species the characters of *Mioclænus* are best seen in the subconical tubercles of the premolars, particularly that of the heel of the fourth inferior premolar. In the other three species this heel is more of a crest and is connected with the principal cusp by a low ridge. The four species may be characterized as follows:

a. Cusps of last premolars conical in both jaws.

Size medium. Last lower molar disproportionately small; cusps low; two anterior inner distinct; true molars, .018 ..... *M. turgidus.*

aa. Fourth superior premolar with flattened external and conic internal cusp; inferior unknown.

Size medium; fourth upper premolor equilateral; all cusps acute; true molars .0165.....*M. subtrigonus.*

aaa. Cusps of last premolars compressed in lower jaw.

Least. Second and third lower true molars subequal; cusps, especially the internal, elevated; anterior inner confluent into an edge; true molars, .013.....*M. angustus.*

Largest; cusps of inferior molars obtuse; P-m. III .008, its heel short and small.....*M. mandibularis.*

Medium; last inferior molar larger than penultimate; true molars, .014; P-m. III .006.....*Anisonchus sectorius.*

Of *M. turgidus* there are two specimens; and of *M. subtrigonus, M. angustus* and *M. mandibularis* one each.

In the *M. turgidus* there are no cingula on the fourth premolar. It is wider than long, and the external face is a little flattened. The tubercles are conic; the external has a small one at the anterior base, and a rudiment at the posterior base, and there is a low one on the posterior side at the middle. The second true molar is wider than the first. The tubercles are all round in section. Besides those already mentioned, there is a rudiment of a posterior inner on the first, which is represented by a cingulum on the second. The latter has basal cingula all around except on the inner side; the same are visible on the first true molar in a rudimental condition. Enamel nearly smooth.

The inferior molars are of robust proportions. Their sizes are, commencing with the largest: P-m. IV; M. II; M. I; M. III. The last molar is only half as large as the penultimate. It has two anterior and an external lateral tubercles, and a heel. On the penultimate molar, there are two anterior tubercles with a trace of anterior inner; also a broad flat heel, with a low tubercle on the external side. The constitution of the first true molar is identical. The fourth premolar has a rudimental heel consisting of a low tubercle only. The principal cusp is conic and is over the middle of the transverse diameter, and a little behind the middle of the anteroposterior diameter. No cingula. Enamel nearly smooth.

Measurements.		M.
Maxillary bone.		
Length of base of P-m. IV, M. I and M. II		.0175
Diameters base P-m. IV	anteroposterior	.0055
	transverse	.0065
Diameters base M. I	anteroposterior	.0060
	transverse	.0070
Diameters base M. II	anteroposterior	.0060
	transverse	.0095
Mandible.		
Length of bases of last four molars		.0250
Diameters P-m. IV	anteroposterior	.0070
	transverse	.0055

Measurements.		M.
Diameters M. I	anteroposterior	.0060
	transverse	.0060
Diameters M. III	anteroposterior	.0055
	transverse	.0043
Depth of ramus at M. I		.0115
Thickness " " "		.0085

MIOCLÆNUS SUBTRIGONUS, sp. nov. Represented by a portion of a cranium anterior to the orbits and lacking the extremity of the muzzle, distorted by pressure. It exhibits nearly all of the molar teeth. The species differs from *M. turgidus* in the greater acuteness of all its cusps, and in the equilateral form of the fourth premolar. It is too large to belong to the *M. angustus*, which is represented by a mandible only; and too small to be the *M. mandibularis*, whose maxillary dentition is unknown.

The inner borders of the molar teeth are shorter than the outer, especially in the last two molars. The last true molar is smaller than either of the others. The cusps are all subconical, but the internal is connected with the intermediate by ridges, which give it a triangular section. The latter form a V, homologous with that in *Anisonchus*, but not so distinct, and the intermediate tubercles are not lost in its branches as in that genus. The posterior inner lobe of that and other genera, is represented by a thickening of the cingulum. This cingulum extends entirely round the P-m. IV and M. I, and M. II; the M. III is injured. The sides of the base of the P-m. IV are slightly concave. The enamel of all the molars is wrinkled.

Measurements.		M.
Length of bases of last five molars		.0285
Diameters of base of P-m. IV	anteroposterior	.0060
	transverse	.0050
Diameters of base of M. I	anteroposterior	.0060
	transverse	.0060
Diameters base of M. II	anteroposterior	.0060
	transverse	.0075
Diameters base of M. III	anteroposterior	.0040
	transverse	.0060

MIOCLÆNUS ANGUSTUS Cope, American Naturalist, 1881, October (September 22d), p. 831. The least species of the genus, with the teeth about the size of *Hyopsodus paulus* Leidy, but with more robust jaw. The molar teeth diminish in size regularly posteriorly from the P-m. IV. They all have three subequal posterior cusps which are less elevated than the anterior ones. The median is enlarged into a heel on the last tooth. The anterior are opposite, and the external is larger than the internal. There is no anterior internal. The external wears into an anteroposterior narrow grinding surface, which looks like a combination with an anterior median. The latter is, however, not separate on the least worn molars. The

anterior outer cusp increases in size anteriorly, and is the large cusp of the P-m. IV. It sends a branch backwards on the inner side of the crown which forms the edge of the narrow concave heel. There are no cingula except a short one on the anterior corners of the base of the crown of the P-m. IV. Enamel obscurely wrinkled.

Measurements.		M.
Length of posterior four molars		.0180
Diameters of P-m. IV	anteroposterior	.0050
	transverse	.0035
Diameters of M. I	anteroposterior	.0050
	transverse	.0035
Diameters of M. II	anteroposterior	.0040
	transverse	.0032
Diameters of M. III	anteroposterior	.0045
	transverse	.0030
Depth ramus at M. I		.0110
Thickness " " "		.0060

PHENACODUS PUERCENSIS, sp. nov. Three individuals. Last superior molar smallest; first and second true molars with six tubercles, two external, two median and two internal. A strong basal cingulum except on inner side. Inferior true molars besides the usual five tubercles, furnished with an anterior ledge with a tubercle at its interior extremity. A weak external basal cingulum. A little larger than the *P. vortmani*. Length of superior true molars M. .021; length of base of crown of M. III .006; do. of M. I .008; width of do. .008; length of base of crown of inferior M. III .0085; width of do. in front .006; depth of ramus at M. I .019.

PHENACODUS ZUNIENSIS, sp. nov. The least species of the genus, represented by the mandibles of two individuals. The first and second true molars are narrowed in front, and there is no distinct anterior ledge, only a minute anterior inner tubercle. The external cingulum is more distinct and the enamel is wrinkled. The fourth premolar has a short base and the inner cusp is much smaller than the principal one; it has a wide heel and an anterior basal tubercle. Length of true molars, M. .018; of last true molar .006; of base of first true molar .006; width of do. .004; depth of ramus at do. .011.

PROTOGONIA SUBQUADRATA, gen. et sp. nov. Fourth superior premolar with one external and one internal lobe. True molars with two external, two internal, and two intermediate lobes, both the latter connected with the anterior internal by a ridge. Supposed inferior true molars with two Vs with weak anterior branches; last true molar with heel.

This genus will enter the *Chalicotheriida* of my system of *Perissodactyla*,* if the feet are found to possess the requisite characters. It is allied, apparently, also to *Hyracotherium*, but differs in the Vs of the infe-

*See Proceedings Amer. Philosoph. Society, 1881, p. 377–8.

rior molars, if they are properly identified; and in the superior molars. The anterior transverse crest of that genus is represented in *Protogonia*, but not the posterior. This is replaced by a low ridge running across the course it pursues in *Hyracotherium*. The posterior median tubercle is also not found in the latter genus. *Protogonia* differs from *Limnohyus* in the subconic character of the external lobes of the superior molars. If the tubercles, excepting the posterior inner, should be converted into crescents, the genus *Meniscotherium* would be produced.

Char. Specif. Probably two specimens; one supporting three superior molars; the other including damaged superior molars and the last two inferior molars. The animal was about the size of the red fox. The external cusp of the fourth superior premolar is flattened externally, and has a small lobe on its posterior edge. The inner tubercle is conic and is separated by a tubercle from the anterior base of the external. True molars without external ridges. The external cusps of the true molars are lenticular in section. The posterior inner cusp is in nearly the same antero-posterior line with the anterior, its section about equaling that of the intermediate cusps. The first and second molars have an external, an anterior and posterior, but no internal, basal cingula. The enamel is somewhat wrinkled where not worn.

The heel of the last inferior true molar is elevated, and its worn surface forms the extended posterior branch of the posterior V. The posterior edge of the penultimate molar is elevated and curved forwards on the inner side of the crown. The anterior cusp forming the angle of the V of this tooth, is higher than the posterior angular cusp, but the anterior limb descends rapidly as in *Coryphodon*. A weak antero-external, and postero-external cingula. Enamel wrinkled where not worn.

Measurements.		M.
No. 1.		
Length of bases of three superior molars		.025
Diameters of superior P-m. IV	anteroposterior	.0066
	transverse	.0086
Diameters of superior M. I	anteroposterior	.0085
	transverse	.011
Diameters superior M. II	anteroposterior	.009
	transverse	.011
No. 2.		
Length of bases of last two inferior molars		.0225
Diameters of last inferior molar	anteroposterior	.0114
	transverse	.0066
Diameters of inferior M. II	anteroposterior	.0112
	transverse	.0080
Depth of ramus at M. II		.0240
Thickness " " "		.0110

MENISCOTHERIUM TERRÆRUBRÆ, sp. nov. My specimens of this species embrace the dentition of several individuals.

The dimensions of the superior molars increase to the penultimate, while the external and posterior sides of the last molar are contracted, reducing its size. The external faces of the external Vs of the true molars are considerably impressed; those of the premolars are nearly flat.

The second premolar is two-rooted, and has a compressed crown, without either heel or cingulum, except a thickening of the posterior base. The base of the crown is triangular. The external plate of the third premolar is simple, and is connected with the internal cusp by a cingulum on the posterior base of the crown. The crown is transverse, and the inner tubercle rather small. The fourth premolar is much larger than the third. Its external plate is divided into two apices, which are not impressed. Their external faces are separated by a faint ridge, and are divided medially by a faint ridge. The anterior external angle is rather prominent. The anterior and a posterior cingulum extend to and round the inner base of the interior tubercle. Within the anterior external apex, is a well developed intermediate crest parallel to it; and there is a corresponding crest within the posterior external apex. This one turns inwards at its posterior extremity, which is on the posterior cingulum.

The anterior angle or horn of each external crescent of the true molars is very prominent. They are sections of short vertical ridges, which unite near the base of the crown, giving abruptness to the impression of the external surface of the anterior lobe. The middle of each face has a faint median ridge. The two molars have an anterior basal cingulum, but no posterior or internal, excepting a trace between the bases of the internal lobes. The anterior intermediate crescent is quite parallel with the external; the anterior internal tubercle has a slightly V-shaped section. The posterior inner tubercle is quite confluent with an oblique intermediate crest, as in *M. chamense*. In the last true molar, as there is only one internal tubercle, this crest is short, terminating at the posterior border. The last true molar is like the last premolar, except in its two impressed external crescents.

A fragment of the right branch of the lower jaw supports two molars, and the alveoli of two others, all of which have two roots. These teeth are the four premolars, although the last one has the form of the first true molar. Should my surmise be correct, then the third premolar has nearly the same form and structure as the fourth. The anterior horn of its anterior V is not produced quite so far inwards as in the fourth tooth. At the point of junction of the adjacent horns of the Vs there is a slight antero-posterior extension, forming a median buttress of the inner side of the crown as in *Anchitherium*. The posterior horn of the posterior V is also incurved, as in that genus. The angles of the Vs of the inferior molars are rounded.

The surfaces of the enamel of the teeth of both jaws is smooth.

Measurements.	M.
Length of superior molars, less P-m. I	.046
" of true molar series	.028
" of base of P-m. II	.005

Measurements.		M.
Diameters of base P-m. III	anteroposterior	.006
	transverse	.007
" of base P-m. IV	anteroposterior	.008
	transverse	.010
" of base of M. II	anteroposterior	.011
	transverse	.013
" inferior P-m. III (or IV)	vertical	.005
	anteroposterior	.007
	transverse	.005
Depth of ramus at same tooth		.012
Thickness ramus at succeeding tooth		.009

The *Meniscotherium terrærubræ* differs from the *M. chamense* in two features. The first is its superior size. The second is the flattened form of the external faces of the true molars and the absence of the convexity of the external bases of the crown.

My specimen of this species is from the red Eocene bed in Northwestern New Mexico, from the true Wasatch horizon, or higher than that which produced the other species here described. It was found by my assistant, D. Baldwin.

Remarks.

As stated in my report to Lieut. Wheeler in 1877, no vertebrate remains had been found in the Puerco beds, which underlie the Wasatch in New Mexico, up to that time. It was therefore uncertain whether they form the top of the Cretaceous or the bottom of the Tertiary series. I have recently obtained evidence of the existence of *Champsosaurus* in them, so that their position might be supposed to be in the Postcretaceous system.

It is however quite possible that the species of Mammalia described in this paper were derived from the Puerco Formation. Their horizon is below the Wasatch, and they represent a different fauna from that of those beds.

Attention has already been directed to this fauna in the pages of the *American Naturalist.** I have recorded the presence of the Creodont genera, *Periptychus*, *Trīisodon* and *Deltatherium*, and of the saurian *Champsosaurus*. I have now added the genera *Hyracotherium* and *Meniscotherium*, and a number of new forms of considerable interest. These are the Creodont *Mesonyx*, a new genus allied to *Esthonyx*, and a series of genera and species with a suilline type of dentition, but whose affinities are by no means certain. This point cannot be determined until the characters of the feet are known.

The facies of this fauna differs in several points from that of the Wasatch. *Coryphodon* has not yet been discovered in it, and the flesh-eaters are very primitive. The suilloid genera are characteristic.

*April, August and October, 1881.

Stated Meeting, October 7, 1881.

Present, 12 members.

President, FREDERICK FRALEY, in the Chair.

Letters of acknowledgment were received from the Society at Stuttgard (105, 106, List); the R. Danish Society (107, 108, XViii); the Dutch Society at Harlem (105, 106, List); the R. Academy at Amsterdam (106); the Zoological Society at Amsterdam (107, 108, XViii); the Agricultural Society at Lyons (102-106); the R. S. of Edinburg (106); the Geol. Survey of Canada (108); and the University of the City of New York (108.)

Letters of envoy were received from the Hungarian Academy; the Royal Academy and Zoological Society at Amsterdam; the Central Statistical Bureau, Dutch Society and Teyler Foundation at Harlem; and the Natural History Society at Hanover.

A letter requesting a copy of Proceedings No. 92, was received from the Meteorological Institute at Vienna.

A letter respecting the "American Catalogue" was received from Armstrong & Co., N. Y.

Donations for the Library were received from the Asiatic Society of Japan; the Russian, Prussian, Hungarian and Dutch Academies, and the Academies at Rome, Turin and Dijon; the Natural History Societies at Moscow, Hanover and Stuttgard; the Observatory at St. Petersburg; the Geographical, Anthropological and Zoological Societies and Geological Institute, in Vienna; the German Geological Society in Berlin; the Statistical Bureau at Harlem; the Zoological Society at Amsterdam; the Entomological Society and Statistical Bureau at Brussels; the Geological Committee of Italy; the Guimet Museum and Agricultural Society at Lyons; the Geographical Society and Society of Sciences at Bordeaux; the Anthropological, Ethnographical, Antiquarian Societies, Polytechnic School, and Political and Literary Review, at Paris; the Society at Cherbourg; the Victoria Institute, Meteorological, Geograph-

ical, Geological, Zoological and Asiatic Societies, Nature and the Cobden Club, at London; the Societies at Cambridge, Falmouth, Leeds, Liverpool, and Edinburg; the Mass. Hist. Society; Peabody Museum; the American Antiquarian Society; the American Journal of Science; the American Journal of Pharmacy; the U. S. Department of Agriculture; the National Museum at Mexico; Mr. Eli K. Price, and Mr. F. Fraley.

The death of Captain Carlile P. Patterson, Superintendent of the Coast and Geodetic Surveys of the United States, was announced by Mr. Fraley.

Resolved, That Mr. Robert Patterson be requested to prepare an obituary notice of the late Mr. William E. Dubois.

Communications were received entitled:—

"Notes on the Coal Field Near Cañon City;" and "Notes on the Quinnimont Coal Group in Mercer Co. W. Va. and Tazewell Co. Va. by John J. Stevenson, Professor of Geology in the University of the City of New York."

Professor Cope exhibited a recently discovered lower jaw of *Triisodon quiverensis* from New Mexico, in an almost perfect condition, with four molars and two premolars of marsupial type. Beneath the premolars are exhibited (by fracture) two perfectly formed successional teeth of carnivorous type. He explained the systematic importance of the fact.

Mr. Lesley, remarked that he thought it had importance also in the transcendental discussion of the development theory; since it represented the form-force of this individual creature as performing its functions of bodily creation under the inspiration of two form-ideas or type-principles at the same time and not in the succession of time. And if this be true of an individual form-force, it supposes the same to be true of the form-force of the world at large.

If in a single jaw we see the process of realizing two distinct organic types at the same moment—the alleged older type not producing the alleged later type by natural generation; nor even preparing for its appearance on the scene—and if we see the two types not separated by any interval of time, and not transcendentally transmuted one into the other through intermediate gradations of type form—then, there is no necessity for seeking any other cause for such intervals or graduations, when apparent in the geological record, except the intelligence of the universal form-force in nature, whatever that may be.

In other words, no theory of natural selection can be used to account

for the presence of a wolf's tooth beneath an opossum's tooth in the same jaw. The creative energy in this case is neither governed by memory, nor by present necessity; but is intelligently prophetic of future emergencies. And that is precisely our simplest definition of *divine providence*. But it is also our simplest definition of *practical invention*. Combining the two, we get the view taken by Mr. Agassiz, instead of the view taken by Mr. Darwin.

Professor Cope exhibited also a very interesting tooth, which he named *Ptilodus mediævus*, from the Lower Eocene of New Mexico.

The importance of this discovery lies in the fact that it furnishes an intermediate link between the *Plagiaulax* of the Jura and the recent Australian *Hypsiprymnus*; which two instances of the general type have hitherto remained separated from each other by the whole Cretaceous and Tertiary interval.

Pending nominations, Nos. 934 to 945 were read.

The expediency of printing certain communications was referred for consideration to the Finance Committee.

On motion of Mr. Fraley, it was

Resolved, That the Society most earnestly recommends the appointment of Mr. J. E. Hilgard, as Superintendent of the Coast and Geodetic Surveys of the United States, believing him to be most eminently fitted for the discharge of the duties of the office, by his long and faithful services in conducting said surveys, and by his skill, ability, and full knowledge of all that is required to make said surveys honorable to the Government and useful to the people.

And the meeting was adjourned.

Notes on the Quinnimont Coal Group in Mercer Co. of West Virginia and Tazewell Co. of Virginia. By John J. Stevenson, Professor of Geology in the University of the City of New York.

(*Read before the American Philosophical Society, Oct. 7, 1881.*)

Bluestone creek, formed at the easterly edge of Tazewell county, Virginia, by the union of Laurel and Mud forks, flows across Mercer and Summers counties of West Virginia to the New river, which it reaches at about four miles south from Hinton, a station on the Chesapeake and Ohio railroad. It receives tributaries from the north, known as Little Bluestone, Mountain, Camp, Wolf, Wide Mouth, Flippon and Simmons creeks. The first four of these rise in an elevated ridge, known as Flat Top, which

separates the waters of Bluestone from those of the Guyandot. But beyond the head of Wolf creek, the streams rise in a narrow ridge, from whose opposite side flow those streams which form the Tug fork of Sandy river. This is a mere knife-edge, so narrow at times as barely to afford room for the country road, which follows its crest.

The surface features of the region on both sides of Bluestone and beyond the divide westward are due wholly to erosion. The carving is stupendous. Standing on any of the high points of Flat Top mountain and looking into Mercer county on the one side or into McDowell and Wyoming on the other, one can compare the surface only to that of an ocean petrified at the height of a terrible storm. But this comparison fails. Narrow ridges, rising to a height of 900 to 1400 feet, separate equally narrow valleys, in which flow rapid streams, carrying much water during a great part of the year. The slopes of these ridges are abrupt, sometimes reaching 35°, and are covered by a dense forest of white oak and poplar (tulip-tree).

The whole region is known as "Flat Top." All the summits between Flat Top mountain and Peters mountain have been planed off to a rudely level surface, a condition wholly independent of the dip, which north from Bluestone varies from 7° to a mere fraction of a degree. Beautifully perfect benches were seen at from 400 to 900 feet above Bluestone creek, in the ridges separating tributaries to that stream, while still higher benches were observed on Flat Top mountain. But as no spirit-level determinations were at hand along Bluestone, no notes were taken respecting the relations of these benches.

The influence of the Abb's Valley fault* is shown along the line of Bluestone, for there the dips are well marked, whereas as one goes northward from that stream, they become insignificant.

Along the New river at Hinton, a fine-grained, grit-like sandstone occurs, which belongs to the Mountain Limestone division of the Lower Carboniferous. It forms a cliff at numerous localities on the Chesapeake and Ohio railroad, both above and below Hinton, and can be traced along New river to the mouth of Bluestone, as well as up that stream to the mouth of Little Bluestone. Higher members of the group appear as one ascends the stream, and the Quinnimont coal group is reached before one comes to the junction of Laurel and Mud creeks, in Tazewell county of Virginia. The top of this group is not caught within the region visited, which extends only to four miles above the mouth of Laurel creek.

A section was obtained on Laurel creek, which does not reach the bottom of the Quinnimont group, but it embraces all of the important beds of the series. It is as follows:

1.	Concealed	70′
2.	Sandstone	10′
3.	Drab Shale	20′
4.	*Purdue Coal bed*	2′
5.	Sandstone	20′

* Described by Prof. J. P. Lesley, Proc. Amer. Phil. Soc, 1872.

6.	Concealed	45′
7.	Sandstone	10′
8.	Shale	0′ 6″
9.	*St. Clair Coal bed*	2′
10.	Sandstone	55′
11.	*Reed Coal bed*	3′
12.	Sandstone	45′
13.	*Tabor Coal bed*	3′
14.	Sandstone	30′
15.	*Coal Branch Coal bed*	9′
16.	Sandstone	70′
17.	*Nelson Coal bed*	11′
18.	Sandstone and Shale	36′
19.	*Coal bed*	1′ 6″
20.	Shale and Sandstone	34′
21.	*Coal bed*	1′
22.	Sandstone	23′
23.	*Coal bed*	Blossom.

The section begins in McDowell county of West Virginia, on the divide separating Bluestone from Tug fork of Sandy river. It was obtained by examinations along Coal branch, Sluss' branch and Haines' Cabin branch, all entering Laurel creek, as well as upon the Tazewell and McDowell road and along Laurel creek itself. Laurel creek flows almost eastward and the head of Haines' Cabin branch is at 7 miles from the mouth of the creek. The top of the section was reached at the head of Haines' Cabin branch and of one fork of Coal branch. The highest beds are not shown, no coal blossom appears in the ploughed fields and only fragments of shale and sandstone are found in the débris covering them.

The blossom of the *Purdue coal bed* was seen on the Tazewell and McDowell road, very near the line between these counties. It was fully exposed near the same road in making an excavation for a spring-house on the Purdue property, where it is said to be 4 feet thick, but the exposure is insignificant now. A very good exposure was found near the head of one fork of Coal branch, at a watering trough on W. L. Reed's land, where very nearly 2 feet of coal are shown. The bed is said to be 4 feet thick in an adjacent hollow, but an exposure near Mr. Reed's house indicates a thickness of not more than 15 inches. The same bed was seen near the Reed school-house on another fork of Coal branch, and at Mr. J. Bailey's house at the head of Haines' cabin branch. It is unimportant at all the exposures observed. The rocks overlying it are shown only on W. L. Reed's property. The massive sandstone, No. 5, is persistent and everywhere marks the place of the *Purdue coal bed.* It is well shown at many places on both sides of the divide.

The interval between the *Purdue* and *St. Clair coal beds* varies from 73 to 80 feet, the former having been found on Haines' Cabin branch, and the latter on Coal branch. The exposure is not complete at any locality visited,

and the character of the rocks filling the interval, No. 6, was not ascertained.

The *St. Clair coal bed* was seen on Coal branch, Haines' Cabin branch and near the head of Sluss' branch, but no full exposure of the bed was found. It was opened at one time on the J. Bailey property near the head of Haines' Cabin branch, where it is said to have somewhat more than 4 feet of coal; but the opening is wholly filled up and only a few fragments of coal remain to show its place. Distinct blossoms were seen at many places near the divide, but none of them indicates a thickness of more than 18 inches. On the St. Clair property near Coal branch, the bed was fully exposed in an excavation for a spring-house and the thickness is said to be 2 feet. But only 19 inches were exposed at the time of examination.

The interval between the *St. Clair and Reed coal beds* is fairly well exposed on a stream leading from the St. Clair house to Coal branch, and contains little aside from sandstone, which varies from massive to more or less flaggy.

The *Reed coal bed* was found only on the waters of Sluss' branch and on the Tazewell and McDowell road. Its place is concealed at all other localities examined. The first exposure is on W. L. Reed's property on a fork of Sluss' branch, where 15 inches of coal are shown in the stream-bed, roofed by 10 inches of shale, underlying sandstone. The coal is prismatic in structure, rather soft, and contains a good deal of pyrites. An exposure on the same property, but on another fork of the stream, shows 2 feet 6 inches of coal, separated from the underlying sandstone by a few inches of clay. The blossom of the bed is shown on the Tazewell and McDowell road, which crosses it at barely a mile from the Nelson coal-pit.

No continuous exposure of the interval to the *Tabor coal bed* was found, but the whole of it was seen. It is occupied by sandstone almost unbroken by shale. The rock is comparatively fine-grained and shows no pebbles.

The *Tabor coal bed* was seen only on Sluss' branch, its horizon being concealed at all other localities examined. The exposures on Sluss' creek are imperfect, there being no opening in the bed. It was opened at one time on Mr. Tabor's property, but the opening has fallen in and only 1 foot of coal is shown. For 6 inches on top it is hard and bony, but below that, the coal as far as seen is good. The same bed is exposed on another fork of Sluss' branch, on W. L. Reed's property, where 3 feet of good coal were seen.

The *Coal Branch coal bed* is best shown on Coal branch at a few yards below the St. Clair crossing, but it is evidently the bed which was once opened on Elkanah Reed's property at the head of one fork of that branch; it was opened at one time in the bluff overlooking Laurel creek above Mr. Nelson's house, and its blossom is fairly shown in the Tazewell and McDowell road, at a little way from Laurel creek. Six feet of coal are exposed by a little run emptying into Coal branch near the St. Clair crossing, where 4 feet of shale separate the coal from the overlying sand-

stone. For 5 feet the coal is soft and clean, but below that is one foot of hard coal which seems to be quite bony. A blossom in the bank of the stream, and 15 feet above the water's edge, was stripped off and showed about 9 feet of coal, but the character and structure of the bed could not be ascertained. Samples for analysis were taken from the exposure in the run, an effort being made to obtain a section of the 5 feet there shown. As analyzed by Mr. A. S. McCreath, the coal has :

Water	1.225
Volatile combustible matter	21.435
Fixed carbon	74.603
Sulphur	0.435
Ash	2.302

It is a coking coal, altogether too soft for shipping. The coke should be of exceptional purity, but the amount of volatile matter is so small as to make the strength somewhat doubtful. No full exposure of this bed was seen on Laurel creek, but at the old opening near Nelson's, on that creek, the thickness is said to be about 6 feet. The bed is nearly 90 feet above Laurel creek at the mouth of Coal branch.

The interval between the *Coal branch* and *Nelson* coal beds is occupied by a more or less flaggy sandstone which forms bold cliffs along Laurel creek and Coal branch. It was not followed above the mouth of that branch. The upper bed rests almost directly on this sandstone and only a few feet of shale separate the cliff from the lower bed.

The *Nelson coal bed* is reached on the Tazewell and McDowell road as one approaches Laurel creek. There, at say one mile above the mouth of Laurel creek, Mr. Nelson has made an opening which has been pushed to about 25 feet. The working does not take in the whole bed, and the exposure at the mouth of the pit is such as to render measurement difficult. As nearly as could be made out, the structure of the bed is as follows :

1.	*Coal*	5′ 4″
2.	Bone	0′ 2″
3.	*Coal*	0′ 6″
4.	Bone	0′ 2″
5.	*Coal*	2′ 10″
6.	Clay	0′ 6″
7.	*Coal*	1′ 0″
		10′ 6″

Nos. 6 and 7 were not seen in detail, and the thicknesses are given according to Mr. Nelson's statement, these parts of the bed having been well exposed at an opening which he had abandoned.

The total thickness of the mined portion is about 7 feet, but there would be no difficulty in taking out fully 8 feet, as only a thin slab of coal need be left to strengthen the roof. Of the part above No. 6, the whole, excepting the two layers of bone, is good, the coal between these being nearly

equal to that of Nos. 1 and 5. The main body, No. 1, is brilliant, but shows many binders of mineral charcoal and an occasional pocket of the same material. No. 5 is not so brilliant as No. 1. The coal throughout the bed is prismatic and very soft, altogether too tender for chipping, but it cokes very readily. Samples from Nos. 1 and 5 were sent to Mr. A. S. McCreath for analysis. He reports the composition as follows:

Water	0.820
Volatile combustible matter	20.580
Fixed carbon	76.182
Sulphur	0.388
Ash	2.030

The only defect of the coal in No. 3, is that it contains some sulphur. This coal should yield a remarkably pure coke, though one not able to bear the burden of a high stack.

No other opening was seen along Laurel creek, but the bed can be followed without difficulty by means of the overlying sandstone down Laurel creek, and thence along Bluestone, but no estimate respecting it can be made from the imperfect exposures. An opening was worked at one time on Laurel creek above Nelson's, but it has been abandoned. There the total thickness is said to be about 11 feet. By means of the overlying sandstone, the bed was followed up the creek to the mouth of Coal branch, above which it soon goes under the stream, which in passing over it forms rapids, whereby the thickness is made to appear very great. The coal is shown for a short distance up Coal branch.

Only the blossom of *Coal bed*, No. 19, was seen. It has been ploughed up on Mr. Nelson's farm, and found to be 1 foot 6 inches thick. Its blossom is shown in a run entering at a little way above Nelson's house. It was not seen elsewhere. No. 21 is in the spring near the house, its only exposure as far as seen. No. 23 was not observed. It is said to be present in the bed of Laurel creek at about 300 yards below Nelson's house.

The dip is nearly 2 degrees at Nelson's pit, but soon becomes very gentle as one recedes from the influence of the Abb's Valley fault. Along Laurel creek the dip is insignificant.

On Simmons' creek, Mr. George Belcher has opened a coal bed at two places. The following measurement was made on his property:

1.	St Clair coal bed	Blossom.
2.	Sandstone	20′
3.	Concealed	50′
4.	Sandstone	35′
5.	*Tabor coal bed*	4′

No. 1 is exposed imperfectly in the road near Mr. Belcher's house, but it has been ploughed up in an adjoining field, where its thickness is said to be somewhat more than 1 foot. The *Purdue coal bed* has been ploughed up near Mr. Belcher's barn, but its thickness was not ascertained. No ex-

posure occurs in the interval No. 3, in which the *Reed coal bed* belongs. At the upper opening in No. 5, the bed is now exposed to a thickness of 2 feet 6 inches, but it is said to be 3 feet 6 inches. The coal is harder than that of any bed fully seen on Laurel creek, but it is broken by many thin partings or binders, mostly of mineral charcoal. Sulphur is present in the top 10 inches, but below that the quantity is insignificant, and the coal is an excellent fuel. The bed is four feet thick at the other opening, and the bottom seems not to have been reached. A large bed, probably the *Nelson*, is said to be exposed at some distance further down the creek, but it was not examined.

A section was worked out hastily on Camp creek, beginning at the crest of Flat-top mountain. It is as follows:

1.	Concealed	60′
2.	Ferruginous sandstone	0′ 10″
3.	Concealed	37′
4.	Yellow sandy shale	6′
5.	*Coal bed*	Blossom.
6.	Clay	1′
7.	Yellow sandy shale	31′
8.	*Purdue coal bed?*	1′ 6″
9.	Clay and variegated shale	15′
10.	Sandstone	30′
11.	Concealed	65′
12.	*St. Clair coal bed* seen	1′ 6″
13.	Sandstone	90′
14.	Shale with *Tabor coal bed*	1′
15.	Sandstone or sandy shale	20′
16.	Concealed, said to contain a *coal bed*	30′
17.	Sandstone and some shale	40′
18.	*Nelson coal bed*, seen	3′
19.	Concealed	10′
20.	Sandstone	25′
21.	Shale and shaly sandstone	30′
22.	Carbonaceous shale	0′ 3″
23.	Shale	16′
24.	*Coal bed*	Blossom.
25.	Imperfect exposure	55′
26.	Sandstone	30′
27.	Shales and sandstone, imperfectly exposed	100′
28.	Sandstone	50′
29.	Sandstones and shales	400′

Ending where the trail leading to Wolf creek crosses Camp creek, at a mile and a half above its mouth. This gives very nearly 600 feet of coal-bearing strata on Camp creek, the rocks below No. 26 being regarded as belonging to the Lower Carboniferous. No calculation for the dip was

made and a closer examination would doubtless lead to a moderate change in the thickness of several of the intervals.

The only coal beds which have been opened are Nos. 8, 12 and 18, but none of these was in shape for measurement at the time of examination. No. 12 is exposed in the bed of the run, and its thickness is said to be nearly 3 feet. The coal is clean, free from pyrites and slates, is soft and should yield a good coke. No. 18 was mined for local use at the junction of the forks of Camp creek. Its thickness is said to be 4 feet 2 inches. The coal is soft, clean and is admirably fitted for blacksmiths' use. No. 24 was once exposed near the creek at half a mile below Reed's mill. The thickness is said to be 3 feet.

The following section of the Lower Carboniferous rocks was obtained in passing from Little Bluestone to Mountain creek :

1.	Conglomerate	20′
2.	Imperfectly exposed	110′
3.	Yellow shaly sandstone	45′
4.	Concealed	25′
5.	Gray to yellow shaly sandstone	80′
6.	Imperfectly exposed	85′
7.	Conglomerate	10′
8.	Concealed	225′
9.	Limestone	3′
10.	Imperfectly exposed	370′
		973′

Exposures of dark red shales occur frequently in the intervals 2, 6 and 10, and No. 10 is made up almost wholly of such shales. This section brings one to the sandstone which forms the river bluffs in the vicinity of Hinton.

Notes on the Coal-field near Cañon City, Colorado. By John J. Stevenson, Prof. of Geology in the University of New York.

(*Read before the American Philosophical Society, October 7, 1881.*)

A small area of Laramie rocks lying along the easterly foot of the Greenhorn mountains has escaped erosion. Its shape is irregular and its breadth varies from two to five miles, being greatest at little more than midway north and south. The total area is not far from 70 square miles.

This little field, which has attained much economical importance, owing to the excellence of the coal from one of the beds, is deeply trenched by several streams which flow across it in cañons with walls from 200 to 500 feet high. The more important of these, beginning at the north, are Alkali gap, Chandler creek, Oak creek, Coal creek and Newland creek. Examinations more or less detailed were made in all except that of Newland creek.

The strike is almost north and south. The dip on the eastern side is gentle, varying from 3 to 6 degrees, and that side of the trough is the longer one. The axis of the synclinal is distinct, passing at about two miles from the eastern outcrop. The dip quickly becomes abrupt on the western side, being first 7, then 10, then 15 and at last 40 degrees where the outcrop is first reached on Oak creek, but the outcrop lies further west both north and south from Oak creek and the dip becomes sharper and sharper until at last the beds are perpendicular or even pushed over.

The following generalized section of the field was made out; but as no opportunity was afforded to revise the work, it may be defective in some of its details:

1.	Sandstones, with some thin shale, not examined in detail	400′
2.	Sandstone, buff, with occasional pockets of shale	45′
3.	*Coal bed* M	Blossom.
4.	Shale and sandstone	165′
5.	Variegated shale	170′
6.	*Coal bed* L	4′ 2″
7.	Shale	14′
8.	*Coal bed* K	0′ 6″
9.	Sandstone	25′
10.	Variegated shale	30′
11.	*Coal bed* J	1′
12.	Shale	24′
13.	*Coal bed* I	3′
14.	Sandstone	120′
15.	Shale and sandstone	25′
16.	*Coal bed* H	5′ 3″ to 9″
17.	Sandstone and shale	46′
18.	*Coal bed* G	1′ 10″ to 2′
19.	Sandstone and shale	30′
20.	*Coal bed* F	4′ 6″ to 0″
21.	Shale	11′
22.	*Coal bed* E	1′ 8″ to 6″
23.	Variegated shale	30′
24.	*Coal bed* D	1′ 10″ to 1′ 3″
25.	Shale and sandstone	25′
26.	*Coal bed* C	4′ 6″ to 6″
27.	Sandstone and shale	50′
28.	*Coal bed* B	4′ to 6″
29.	Shale	30′ to 20′
30.	*Coal bed* A	6′ to 10″
31.	Shale	10′
32.	Sandstone	70′ to 100′

The same difficulty was experienced here as in the *Trinidad coal field*,

further south. Limestones are absent and the sandstones show abrupt changes in composition. Direct tracing around the points of bluffs is not always practicable, and identifications of coal beds in different cañons are based largely on the intervals found in the typical section obtained on Oak creek. As these intervals are by no means constant, some of the identifications may prove to be erroneous.

The eastern outcrop of the field is well marked by bluffs and it cannot be mistaken, except in the extreme northern part, where erosion has carried away the lower beds and the bluffs contain only the higher members of the series. The sharp hogbacks in which the beds are turned up at angles varying from 40 to 90 degrees, mark the western limit sufficiently well, except in the southern part of the field where erosion has beveled off the surface of the mesa. But even there, exposures are found on the larger streams which enable one to follow out the limit with but little difficulty.

Coal mines have been opened at several localities along the eastern side of the trough and branch roads have been constructed by the Atchison, Topeka and Santa Fé and the Denver and Rio Grande railroad companies, leading to mines owned or controlled by those companies. Insignificant openings only were seen along the western outcrop, but some pits on the northern side of the field have been worked somewhat extensively to supply Cañon City.

Exposures are infrequent on the northern edge of the field, where a deep covering of gravel conceals all the rocks even to the tops of the hills; while beyond the sharp ridge bounding the field, a basin has been eroded and rocks are rarely seen in place. The few openings seen afforded no data for determining the position of the beds in which they have been made. A similar difficulty was encountered on the north-eastern side of the basin where the lower beds of the series are buried under the alluvial coating of the plain, and only the higher beds are shown in the bluffs. Some *coal* blossoms and an extensive opening were seen here, but their position was not determined, further than they belong to the upper part of the section.

Alkali Gap. The stage-road leading from Cañon City to Silver Cliff passes through this gap at about 4 miles from Cañon City. The exposures are excellent for a distance of nearly 400 yards, but as soon as one enters the basin into which the gap opens, all exposures cease. The following section was obtained in this gap, the thicknesses of the several beds being determined by pacing and calculation from the dip:

1.	Conglomerate	239′
2.	Sandstone	168′
3.	Concealed	40′
4.	Sandstone	128′
5.	Shale	3′
6.	Sandstone	69′
7.	Concealed	42′

8.	Sandstone	6′
9.	Concealed	122′
10.	Sandstone	10′
11.	Concealed	12′
12.	Sandstone	8′
13.	*Coal bed*	5′
14.	Sandstone	6′
15.	Concealed	20′
17.	Shale	5′
18.	*Coal bed*	2′
19.	Imperfectly exposed, much whitish sandstone	75′
20.	Sandstone	10′
21.	Concealed	160′
22.	*Coal bed*	3′ 2″
23.	Clay	1′
24.	Sandstone	30′

With this all exposures cease along the line examined, but Mr. Alex. Bowie, local superintendent of the coal mines at Rockvale on Oak creek, states that another bed of *coal* has been seen by him below the sandstone. Unfortunately no determination of the distance was made by him.

The conglomerate at the top of the section is very coarse and altogether unlike any rock seen elsewhere in the field. If Mr. Bowie's observations be accurate, this rock is higher in the series than any exposed in the typical section obtained on Oak creek and it has been eroded from the mesas in the southern part of the field, from Chandler creek southward. The sandstones down to No. 12 are soft, with a yellowish tint and readily disintegrate when exposed to the weather. Thin beds of shale occur here and there in the upper part, but are not persistent and they have been ignored in making up the section.

The *Coal bed*, No. 13, is exposed at the roadside as one enters the gap from the west. Its dip is 85 degrees at the top of the shaft and 75 degrees at the bottom. No detailed measurement was made as the shaft has been abandoned and the edge is unsafe. The bed shows five benches of *coal*, with a layer of dark shale fully 5 inches thick. A parting of sandy clay, nearly 2 inches thick, appears to be persistent. *Coal bed*, No. 18, has been opened by a shaft probably 20 feet deep. The dip is irregular but is somewhat more than 75 degrees. The *coal* so far as exposed is friable and worthless. No bed was seen between this and No. 24, but Mr. Bowie states that another bed exists in this interval and that it is shown at a little way from the line followed. It is 1 foot 7 inches thick and contains very fair coal. No. 22 dips at 85 degrees, almost due east; it is in four benches, separated by thin partings of sandy shale. It has been opened by two shafts, each about 20 feet deep; but the coal as far as seen is badly broken by exposure to the weather.

In the absence of detailed measurements below the bed, No. 22, one may not undertake to identify these beds with any in the Oak creek section;

but it may be that they represent *Coal beds* C, I and L. The associations of the lowest bed suggest reference of it to *bed* C.

Chandler creek. The cañon of this stream crosses the field and affords very fair exposures of the upper part of the section; but erosion has been active at both ends of the cañon, so that the lower beds have been removed and for the most part they are now buried under gravel on the broad elevated terrace. A boring made at the mouth of the cañon, at a little way east from the foot of the bluffs, begins in sandstone, No. 14 of the general section, and continues to the depth of 301 feet 9 inches. The record of the boring as furnished by Mr. Alex. Bowie, is as follows:

1.	Gravel	30′ 6″
2.	Sandstone	40′
3.	Shale	7′ 6″
4.	Sandstone	1′ 4″
5.	Shale	6′ 10″
6.	*Coal bed*	4′ 1″
7.	Hard sandstone	3′ 9″
8.	Soapstone	52′
9.	Sandstone	6′
10.	Soapstone	58′ 4″
11.	Sandstone	5′ 4″
12.	Shale	48′ 2″
13.	*Coal bed*	5′ 5″
14.	Soapstone	8′ 9′
15.	Sandstone	2′
16.	Soapstone	1′ 4″
17.	Sandstone	6′
18.	Sandstone and shale	14′ 5″

The upper bed seems without doubt to be *Coal bed* H, though it is much thicker here than at any other locality examined. The structure as shown in the boring is:

Coal, 1′ 3″; clay, 11″; *coal*, 1′ 11″.

The lower bed is usually thought to be the same with *Coal bed* A, the bed mined on Coal creek by the Colorado Coal and Iron Company, but the interval to the upper coal is very nearly the same with that obtained between *Coal beds* H and C on Oak creek, barely a mile away; so that the lower bed is more probably *Coal bed* C, the bed worked in shaft No. 2 of the Cañon Coal Company. Its structure as shown in the boring is:

Coal, 3′ 4″; clay, 11″; *coal*, 1′ 2″.

A number of borings have been made along Chandler creek, but the records are not accessible. The trough becomes deep in this cañon, and at the bottom of the synclinal, *Coal bed* A is fully 800 feet below the surface. The walls of the cañon are low and the cañon itself is very broad, especially near the line of the axis. No trace of the great conglomerate of Alkali gap was observed here.

Beyond the axis of the synclinal, the rocks rise rapidly westward and at the head of the cañon one is brought very near to the horizon of *Coal bed* H. An opening has been made in a bed at a little way beyond the head of the cañon, but in the absence of all exposures near at hand, the place of the bed could not be determined. The lowest sandstone of the group is reached at a short distance beyond and shows the same features as those to be described on Oak creek. The middle Cretaceous rocks lie immediately behind the great sandstone and continue thence to the foot of the mountain, where the Dakota rests on the metamorphic rocks. The transition from the Coal group to the Fort Pierre is very gradual and no line of separation can be found.

Oak creek. The cañon of this stream follows a north-easterly direction across the field and affords by far the best series of exposures. It is followed by the Coal branch of the Atchison, Topeka and Santa Fé railroad to Rockvale, where the Cañon Coal Company has sunk the shaft, No. 1, with the view of working *Coal bed* A. The outcrop of that bed is poorly shown in this cañon along the eastern side of the field, but that of *Coal bed* C is frequently exposed. Shaft No. 2 of the Cañon Coal Company opened this bed and a slope is under way to reach the same bed for the Colorado Coal and Iron Company. The section at shaft No. 2, including the measurements in the shaft, is as follows :

1. Sandstone, seen on the bluff	15′
2. Shales	10′
3. Concealed to curb of shaft as estimated from the dip	120′
4. Clay and gravel in shaft	30′
5. Shale and thin sandstone	31′
6. *Coal bed* E	1′ 6″
7. Shale and thin sandstones	47′ 6″
8. *Coal bed* C	4′ 6″
9. Fireclay	0′ 5″

A coal blossom, indicating a thickness of about 8 inches, was seen at a few rods east from the shaft. Allowing for the dip, this bed belongs near the middle of the gravel at the top of the shaft, and is therefore *Coal bed* G. *Coal bed* E contains very good coal, but as it is not of workable thickness, no tests have been made to determine its value. *Coal bed* C is mined in the shaft where its structure is

Coal, 2′ 2″ ; clay, 2″ ; *coal*, 1′ 9″ to 2′ 2″.

An outcrop on the opposite side of the valley shows the bed 3 feet 10 inches thick, as reported by the local superintendent of the company, and there the parting is present also. But lower down the stream the bed becomes very thin and at several exposures it is insignificant. In the shaft it yields an excellent coal, which is hard, must be blasted but comes out in large blocks. The underlying fireclay aids much in mining, but it is soft and is likely to be a source of annoyance in the immediate vicinity of the shaft. The dip is a little south of west at 5 degrees.

The sandstone, No. 1 of the section, caps the bluff directly north from the shaft and is easily followed to Rockvale, where it is alongside of the railroad. The Cañon City Coal Company's shaft No. 1 begins in this rock. A boring was made in creek bottom at about 500 feet from the shaft and it begins in this rock, though somewhat higher than the top of the shaft. The record of the boring is

1.	Sandstone	82′	
2.	Shale	17′	
3.	White sandstone	7′	3″
4.	*Coal bed* H	0′	9″
5.	Sandstone	10′	3″
6.	Soft shale	4′	
7.	Sandy shale	31′	4″
8.	*Coal bed* G	1′	4″
9.	Sandstone, hard	15′	5″
10.	Argillaceous shale	3′	8″
11.	Sandy shale	18′	
12.	*Coal bed* E	0′	6″
13.	Sandstones and shales in thin beds	52′	8″
14.	Black shale	5′	4″
15.	Sandstone	2′	
16.	*Coal bed* C	0′	8″
17.	Sandstone and shale	3′	7″
18.	Black shale	21′	3″
19.	Sandstones and shales	20′	10″
20.	*Coal bed* B	0′	6″
21.	Black shale	22′	1″
22.	*Coal bed* A	3′	4″
23.	Arenaceous shale	9′	7″
24.	Black shale	5′	
25.	Sandstone and sandy shale	5′	1″
	Total	341′	6″

The company's shaft at the time of examination was down 220 feet. *Coal beds* G and H are thicker in the shaft than in the boring, the former being 1 foot 2 inches and the latter 1 foot 10 inches. The great sandstone, No. 1 of the section, is nearly 120 feet thick. It varies somewhat in structure, as is well shown in the railroad cut at Rockvale. In the boring it seems to be a compact sandstone throughout and it shows a similar structure in the shaft, but in the railroad cut, only a few yards from the shaft it becomes shaly toward the middle, there being not less than 29 feet of shale exposed in the cut. The rock is mostly massive, soft and reddish-yellow to buff and bluish gray. It contains vast numbers of *Halymenites major*, of which excellent specimens can be obtained at Rockvale. This fossil is most abundant in the upper part of the rock.

The bluff immediately north from the shaft at Rockvale affords good exposures of the overlying beds. The section obtained on this bluff is as follows:

1. Sandstone..... 20′
   This is buff, soft, weathering with honeycombed surface, but contains a hard reddish band, only a few inches thick.
2. Sandstone..... 45′
   Very like the last, but containing some shale, which decreases westward until both sandstones are practically one.
3. *Coal bed* M..... Blossom.
   This may be only a carbonaceous shale.
4. Shales and sandstone..... 61′
   Where the section was taken this seems to be almost wholly variegated shale, but within 50 yards it has a bed of massive sandstone, buff or yellow, soft and covered with a thin band of hard red sandstone.
5. Sandstone..... 8′
   Yellow, where examined, more or less ferruginous, with small nodules of carbonate of iron; at a little distance further up the creek, it becomes buff like the higher beds and weathers into rounded bosses. This is a marked and persistent bed, which remains above the surface to the bottom of the synclinal at the forks of the creek. It has on top a thin bed of flaggy red sandstone, which is very hard.
6. Shale..... 87′
   Variegated, with some thin beds of sandstone, 1′ to 2′ thick, which are more or less argillaceous; here and there is a band of carbonaceous shale; possibly some coal may belong in this interval but none was recognized.
7. Sandstone..... 9′
   Very like No. 5.
8. Shales..... 186′
   Variegated; for the most part well exposed, but the exposure is incomplete toward the base, where two black streaks were seen, the blossoms of *Coal beds* K and L. This mass is persistent. It passes below the surface before the synclinal axis is reached, but re-appears on the west side in in the bluff at the head of Oak creek cañon.
9. Sandstone..... 25′
   Hardly differing in general features from No. 5.

10. Variegated shales ..... 30′
11. *Coal bed* J ..... 0′ 10′
    Represented only by carbonaceous shale, where the section was measured; but it has been opened elsewhere on the bluff, with a thickness of 1′.
12. Shale ..... 24′
    At the base of this is a very friable sandstone, almost white, which is persistent.
13. Concealed ..... 25′
    This is calculated from the dip as the interval between the base of No. 12 and the top of the sandstone in which the shaft begins. Exposures in the vicinity indicate that this is occupied in part at least by shales at the base of which is *Coal bed* I. That bed is not exposed here.

This bluff is continuous to the cañon of Chandler creek, and the same section is exposed at the mouth of that cañon. The sandstones of the section are all light yellow or buff, and almost without exception have a band of hard red flaggy sandstone as the top layer. Search was made in all these red beds, but no fossils were found aside from the *Halymenites*, and that has its upper limit in the great sandstone at the top of the shaft. Occasional impressions of fossil dicotyledonous leaves were seen, and a fine *Sabal* has been brought out of the shaft No. 1. The dip here is somewhat more than 3 degrees and almost due west.

South Oak creek enters the main stream at Rockvale and flows northwardly. The great sandstone with *Halymenites* continues in sight along this stream for nearly two miles. At the first fork of the stream the top of that rock is reached, and there *Coal bed* I is well exposed, with the following structure:

1. *Coal*	.....	8½″
2. Clay	.....	½″ to 1″
3. *Coal*	.....	9½″
4. Sandy clay	.....	1″ to 1½″
5. *Coaly* shale	.....	2″ to 4″
6. *Coal*	.....	11″ to 13″
Total	.....	2′ 11″

The coal is evidently poor throughout. The bed is overlaid with shales succeeded by the friable white sandstone seen near Rockvale. Streaks of coal are shown in the shale at a little way further up the creek. At say a mile further up the main stream its cañon and that of a gulch leading into Bluff Spring park, a tributary to Coal creek, come very closely together. There the shales, No. 8 of the Rockvale bluff, are reached, but no exposure of *Coal beds* K and L was found.

Following up Oak creek above Rockvale, one sees the rocks descending, until the sandstone, No. 5 of the Rockvale section, is the lowest bed ex-

posed. Near the line of the synclinal axis a cañon opens from the north, at whose head is a fine exposure of the higher beds. But there was no opportunity to examine this in detail, and the thickness of the beds overlying the Rockvale section was estimated at 400 feet. They are chiefly buff sandstones, with comparatively thin beds of shale, which vary greatly in thickness and may be regarded only as partings of the sandstone. No traces of coal have been observed in these higher beds. The synclinal axis crosses Oak creek very near the forks of the stream.

A boring was made some time ago by the Colorado Coal and Iron Company on Oak creek, at a little way below the crossing of the synclinal. The curb of the boring is but a few feet under sandstone, No. 5 of the Rockvale section, and *Coal bed* A was reached at 571 feet. The record of the boring is not accessible and the depth is given according to indirect information.

The section to *Coal bed* H is shown in the bluff at the head of Oak creek cañon, and that *coal bed* was opened some years ago, by Mr. Nelson, just south from the cañon; but the opening was abandoned, owing to inferiority of the coal. The condition of the pit when visited was not such as to afford exact measurement. The bed is said to be 5 feet 3 inches thick, with a shale parting near the middle. Drab shales overlie it, separating it from the light gray sandstone, above which, at a few feet, is the great yellow sandstone. When freshly mined, the coal is said to look well, but after short exposure it slakes. The dip at this pit is eastward at nearly 40 degrees.

At nearly a mile further south along the bluff, *Coal bed* I was seen above the yellow sandstone, showing:

Coal	1″
Clay	1′
Coal	1′ 2″

But the crop coal is very poor. Higher up on the hill-side, *Coal bed* K was seen 6 inches thick, while at a few feet higher is *Coal bed* L, showing:

Coal	2′ 6″
Clay	6″
Coal	1′ 3″

The bed makes a formidable blossom, but the exposure does not suffice to indicate the quality of the coal. The great mass of shale, No. 8 of the Rockvale section, contains much friable sandstone here, which breaks down even more readily than the soft clay shales seen further down the the creek. The sandstone, No. 5 of that section, is persistent here and is easily recognized, though it is somewhat harder than at Rockvale.

The outcrop of *Coal bed* A is shown in a low ridge west from the Nelson opening, and the road leading to Mr. Bishop's ranch passes over it. The exposure is imperfect here and the bed is much better shown at a little way further north, where it was opened by Mr. Bassick near the stone cabin. This opening was abandoned because the abrupt dip, more than

40 degrees, made raising the coal by horse-power too difficult for profit. The crushed outcrop at this pit shows a thickness of nearly 20 inches, but the bed is said to show 3 feet of good coal at the end of the slope. The overlying shale is thin and is covered by a yellow sandstone.

A low mound rises in the park between this ridge and the bluff. A *coal* blossom was seen here, but its place was not determined, though the bed is probably C. The blossom indicates not much coal.

Followed southward the yellow sandstone associated with *Coal bed* A is seen forming a sharp low ridge, which continues southward to the head of Oak creek, where it is lost in the mesa. At the head of Oak creek cañon a park intervenes between the bluff and the sandstone ridge; but southward the park becomes narrow and at length the mesa and the low ridge are united. An exposure on Mr. Bishop's ranch, near the point of union, shows the following section:

1.	*Coal bed* C?	0′ 7″
2.	Shale and some sandstone	22′
3.	*Coal bed* B?	0′ 2″
4.	Shale	36′
5.	*Coal bed* A	3′ 10″
6.	Shales, sandy, not fully exposed	15′
7.	Deep yellow sandstone, estimated	100′

The identification of the smaller coals is only provisional, there being no other detailed measurements on this side of the field for comparison. The coal of bed A appears to be by no means bad and the crop coal has a bright fracture. The dip is vertical here and the bed can be followed easily from this place to where it passes into the mesa.

The sandstone below the coal is the lowest bed of the Coal group. The upper part is hard sandstone, honey-combed with films of quartz, and holds thin beds or pockets of conglomerate in which the pebbles vary in size from buckwheat to pea. The color varies from cream to deep reddish yellow, and in most respects the rock is an almost exact duplicate of the Dakota sandstone, which is exposed within a short distance at the foot of the Greenhorn mountains. The lower part of the mass becomes more or less shaly, and at length passes into a series of dull reddish shales, somewhat sandy but mostly argillaceous, and showing little structure. These in their turn pass almost imperceptibly into the Fort Pierre shales, which are well exposed at the head of Oak creek, where they hold the customary septaria and abundance of selenite. The thickness of the dull beds below the sandstone was not measured on Oak creek, but it appears to be not far from 100 feet.

The Niobrara and Fort Benton groups are fairly well shown at the head of the creek and as far down as Mr. Bishop's ranch; but no effort was made to determine their thickness. The Dakota is exposed on a tributary of Oak creek, where it is said to contain a thin bed of fairly *good coal*. This has been opened and the whole space underlaid by the Dakota has been taken up as coal land. The guide was unable to find the opening.

but there seems to be no doubt that it exists and that the coal is there. The upper member of the Dakota shows the usual features, but the lowest member is a coarse conglomerate, 10 or 15 feet thick, which is made up of fragments of the coarse gneissoid granite on which it rests. These fragments have suffered little from water, and the conglomerate can be distinguished only with difficulty from the underlying granite.

No exposures occur on the mesa between Oak creek and South Oak creek, aside from fragmentary exhibitions of sandstones, which barely suffice to indicate the dip, and give no information respecting the succession of the beds.

Coal Creek.—Coal creek is followed by a branch of the Denver and Rio Grande railroad, leading to the mines of the Colorado Coal and Iron Company. One branch of the stream flows northward along the eastern edge of the field, while several tributaries flow to it from the west, each of which has eroded a cañon, exposing a large part of the section. Examinations were made along several of the streams.

At the mines of the Colorado Coal and Iron Company, on Coal creek, the following exposure was found:

1. *Coal bed* C	0′	8″
2. Shale and sandstone	50′	
3. *Coal bed* B	0′	10″
4. Shale	30′	
5. *Coal bed* A	6′	2″

And the dip is N. 30° W. mag.

Coal bed C, the same with that mined in shaft No. 2 of the Cañon City Coal Company, on Oak creek, is represented here only by a little carbonaceous shale. *Coal bed* B is well shown on the face of the bluff, and descends with the road from the top of the hill. *Coal bed* A is mined extensively and yields a superior coal, which is used in the railroad engines and is shipped largely to be used as fuel at Denver and other cities of Colorado. The bed shows the following structure at the mouth of the slope:

Coal	1′	
Clay		7″
Coal	4′	7″

At half a mile further up this branch of Coal creek, the same bed is mined by the Grand Cañon Coal Company. The bed was not measured here, but the thickness is reported by the President to be 3 feet 6 inches, and the quality is regarded as equal to that of coal from the other mine. Only the lower division of the bed is present in the slope. The upper division is merely a "rider" coal, and the interval between it and the main body varies from zero to 11 feet; the latter interval being seen at the Cassidy slope, while the two divisions are in contact at many places in the Colorado Company's mine. The rider is distinctly shown in the gulch at the Cassidy slope.

Following up the gulch for half a mile, the following section was obtained:

1.	Sandstone	15′
2.	Shale	2′
3.	*Coal bed* G	0′ 6″
4.	Shale and thin sandstone	15′
5.	Sandstone	5′
6.	Black shale	8′
7.	*Coal bed* F	4′ 6″
8.	Bluish shale	11′
9.	*Coal bed* E	1′ 8″
10.	Variegated shale	28′
11.	*Coal bed* D	1′ 3″
12.	Shale and thin sandstone	25′
13.	*Coal bed* C	Blossom.
14.	Sandstone and shale, estimated	45′
15.	*Coal bed* B	1′ 2″
16.	Shale	16′
17.	*Rider coal bed*	0′ 10″

Coal bed B is shown on the low hill alongside of the road, at a few rods above the trestle; it seems to be hard and fairly clean coal. The upper part of the interval, No. 14, is occupied by a massive, soft, yellowish white sandstone, which is about 20 feet thick. *Coal bed* C is represented by carbonaceous shale, which was followed up the gulch to where it passes under the surface. The interval between it and *Coal bed* D was estimated. The rest of the section was obtained on a projecting point opposite a gap in the hill, lying between the road and the gulch. *Coal bed* D is shown on both sides of the stream, but is thicker on the southerly side, where it shows 22 inches of coal.

Coal bed F appears on the bluff, where its blossom measures 4 feet 6 inches, but a good exposure occurs at a few yards further up the gulch, which exhibits the structure of the bed in detail as follows:

Coal	0′ 5″
Parting	— —
Coal	1′ 7″
Clay	0′ 2″
Coal	0′ 9″

The coal is sulphurous and dirty, so that it is of little value. The overlying shale is fissile and very black. *Coal bed* G is exposed under the edge of the sandstone which caps the bluff. This rock is reddish-yellow, mostly massive and occurs in cliffs. The thickness appears to be upwards of 40 feet, but exposures further south show that *Coal bed* H belongs at but a little way above *Coal bed* G, and the thickness of the lower sandstone is not more than 15 feet. The rock above *Coal bed* H is the one form-

ing the top of the mesa, and its cliff is shown at a little way back from the top of the bluff overhanging this gulch.

Crossing the narrow divide to Bluff Spring park, one passes over the great sandstone in descending to the park. The spring issues from almost directly underneath the sandstone, No. 1 of the last section, but *Coal bed* G is not exposed. The sandstone overlying *Coal bed* F caps a little mound in the park, and that *coal bed* has been exposed there with a thickness of 2 feet 6 inches. The overlying shales are not black, the carbonaceous matter having disappeared. The road leading from Bluff Springs park to the Shaw gulch passes under a bluff, immediately beyond the park, where *Coal beds* E and F are exposed. The latter is but 1 foot 6 inches thick, but the former shows:

Coal, 8″; clay, 4″; *coal*, 1′.

The coal is very poor. The shale above *Coal bed* F is brown and yellow, carbonaceous matter being wholly absent. No prospecting has been done in Bluff Spring park below the line of the wagon road, and *Coal bed* A has not been recognized.

The massive yellow sandstone overlying *Coal bed* H is easily followed across the low divide separating Bluff Spring park from the Shaw gulch. In this short gulch, the Cañon Coal Company have mined *Coal bed* F, known as the *Shaw coal*. The coal has been hauled 4 miles in wagons, to be shipped at Rockvale. It underlies a thin gray sandstone and the shales intervening are lead-colored. The structure of the bed as shown in the mine is:

Coal	0′ 7″
Parting	— —
Coal	1′ 5″
Parting	— —
Coal	1′ 4″

The thickness in this mine varies little from 40 inches. The coal is good and has been used extensively on the engines of the Atchison, Topeka and Santa Fé railroad; but the engineers think it inferior to coal from *bed* A.

Coal bed G is found here at 22 feet above F and is insignificant. *Coal bed* H is very thin and but 17 feet above G. The Great sandstone forms a bold cliff here and, according to Mr. Bowie's measurement, it is 75 feet thick, thus showing a decided diminution in thickness southward. *Coal bed* I rests on the sandstone and, where explored immediately north from the Shaw gulch, is 22 inches thick.

The next gulch southward is that known as Bailey's gulch. It is barely half a mile from the Shaw gulch and affords a good exhibition of the measures. The following section was measured there by Mr. Bowie, who has kindly given me the use of his record:

1. Black shale	3′
2. *Coal bed* K?	3′

3.	Shale	0′ 6″
4.	Gray sandstone	10′ 6″
5.	Black shale	1′
6.	*Coal*, divided midway by shale, 1″, J	2′ 5″
7.	Shale and gray sandstone	18′ 3″
8.	*Coal bed* I	0′ 3″
9.	Shale	1′
10.	Gray sandstone	13′ 6″
11.	Yellow sandstone	60′
12.	Shale	1′
13.	*Coal bed* H	0′ 6″
14.	Shale	1′ 6″
15.	Gray sandstone	15′
16.	*Coal bed* G	1′ 6″
17.	Shale	1′
18.	Gray sandstone	7′
19.	Black shale	14′
20.	*Coal bed* F	3′ 4″
21.	Shale	7′ 9″
22.	Sandstone	4′ 6″
23	Shale	8′ 6″
24.	*Coal bed* E	1′ 6″
25.	Shale	38′ 3″
26.	*Coal bed* D	3′
27.	Interval	61′
28.	*Coal bed* B	4′
29.	Argillaceous shale	30′
30.	*Coal bed* A	0′ 10″
31.	Shale	0′ 10″
32.	Argillaceous sandstone	14′ 6″
33.	Yellow sandstone	150′

The lettering of the coal beds is in accordance with the generalized section. *Coal bed* C is not given in this section; it is exposed at the point of the bluff between Bailey and Shaw gulches at 33 feet above *Coal bed* B. An imperfect exposure made with the hammer showed 2 feet of coal, but neither the top nor the bottom of the bed was reached.

Coal bed G varies from 2 inches to 18 inches. *Coal bed* F is well shown in the bed of the gulch, where the structure is clearly the same as in Shaw gulch. *Coal bed* E is imperfectly exposed in the stream bed; but *Coal bed* D is well shown in the side of the gulch where it has been prospected. *Coal bed* B has been opened at the end of the bluff where the thickness is as given. *Coal bed* A is utterly insignificant here, being but 10 inches in Mr. Bowie's section and 14 inches where seen in the gulch by the writer.

The great sandstone at the base of the section is reached just east from the mouth of the gulch. It has the same characteristics everywhere along the east face of the field. The thickness as given by Mr. Bowie is per-

haps the extreme, for the mass is not invariably a compact sandstone, but often shows great beds of sandy shale, sometimes even clay shale, the whole merging into the clay beds or beds of passage to the Fort Pierre shales.

Newland Creek. This is the next stream southward and makes a cañon across the whole of the field. But no detailed examinations were made there. A distinct though gradual rise of the whole basin southward carries out the highest members of the series before Newland creek is reached, so that almost midway in the basin, the great sandstone with *Halymenites* is at the top of the mesa. The measures above that sandstone are probably not more than 150 feet thick and no exposures were found to yield a section. Mr. Bowie's observations along the eastern face of the field at and beyond Newland creek show that the *coal beds* become thicker than they are further north, as indeed is suggested by the section in Bailey's gulch. A thick bed is worked on a tributary to Newland creek, which Mr. Bowie thinks is equivalent to the Shaw coal. The section of the bed as given by him is:

Coal	1′ 8″
Clay	0′ 7″
Coal	2′
Shale	1′ 2″
Coal	1′

Relations of this field.

Careful search was made everywhere for fossil remains, but nothing was found aside from the fucoid, *Halymenites major*, and some palm leaves. *Halymenites* occurs abundantly in the sandstone overlying *Coal bed* H, and a few specimens were observed in the sandstone at the base of the series, which was examined at but two localities. The palm leaves were obtained in the Rockvale shaft, at fully one hundred feet below *Coal bed* H. The thickness of measures included between the upper and lower limits of the fucoid is more than four hundred feet.

This distribution of the fucoid is of no little interest. The writer* has shown that along the South Platte river, north from Denver, *Halymenites* occurs throughout a great mass of sandstone, where it is associated with forms proving the rock to belong to the Fox Hills group of the Upper Cretaceous. Dicotyledonous leaves occur there in the same sandstone.

In the Trinidad coal-field of southern Colorado and northern New Mexico, the writer† recognized a persistent sandstone, 60 to 80 feet thick, as marking the base of Laramie group. This sandstone, which occasionally holds a coal bed, contains *Halymenites major* in profusion, while that fossil occurs neither above nor below this horizon. At one locality, the the sandstone contains a *Cardium*-like mollusk, but the specimens obtained are too indifferent for specific determination.

* Am. Journ. of Science, 3rd Series, Vol. xvii, p. 370.
† Amer. Journ. of Science, 3rd Series, Vol. xviii, p. 132.

Along Galisteo creek, in central New Mexico, as well as on the Rio Grande, 100 miles further south, the writer has sought in vain for specimens of the *Halymenites*, both in 1879 and 1881. The fucoid seems to be wholly wanting in the Laramie area of central New Mexico.

Comparing the distribution at the several localities mentioned, we have as the vertical extent of the fucoid :

In northern Colorado, along South Platte.....	700′+
In central Colorado, Cañon City field.....	400′
In southern Colo. and northern N. M., Trinidad field.	80′
In central New Mexico, Galisteo creek and Rio Grande.	0′

Halymenites major, along the eastern foot of the Rocky mountains, is as thoroughly diagnostic of the Fox Hills group a *Arthrophycus harlani* is of the Medina sandstone in the Appalachian region. The *Halymenites* sandstone of the Trinidad field, the lower 400 feet of the Cañon City column, and the enormous mass of sandstone on the South Platte, below St. Vrain's creek, are equivalent and represent the Fox Hills group, as generally accepted. Coal occurs in them all, but most abundantly in the Cañon City area. It should not be forgotten, however, that the South Platte locality is at 70 miles from the mountains. When the section has been made from the mountains to that locality, not a little of the productive coal series will be found represented on the Platte by this sandstone group.

The Fox Hills group, as generally accepted, thins out southward and finally disappears before reaching central New Mexico.

Stated Meeting, October 21, 1881.

Present, 15 members.

President, FREDERICK FRALEY, in the Chair.

Mr. Aubrey H. Smith presented his photograph for the album.

Letters of envoy were received from the Second Geological Survey of Pennsylvania, the Johns Hopkins University, and the Geological Survey of the United States.

Donations to the Library were received from the Gazette Hongroise; J. M. Schary's heirs, Prag; Royal Institute, Venice; Revue Politique; Royal Academy, Brussels; Nature; Essex Institute; S. H. Scudder; Board of Education, Providence, R. I.; Wesleyan University; Silliman's Journal; New York Academy of Science; Franklin Institute; Medical Jour-

nal and News; E. D. Cope; H. Phillips, Jr.; Geological Survey of Pennsylvania; American Journal of Mathematics; U. S. Geological Surveys; Commissioners of Education; J. Hotchkiss; A. W. Williamson, and the Geological Survey of Canada.

The deposit of the late Prof. J. F. Frazer's portrait in the Hall of the Society, by his son Prof. Persifor Frazer, during his absence in Europe, was on motion ordered to be placed on the minutes.

Mr. Patterson accepted by letter his appointment. (See last meeting.)

The following letter was read:

"*To the Secretary of the American Philosophical Society.*

DEAR SIR:—In reply to your inquiry under date of the 10th instant, it may be briefly stated that Carlile Pollock Patterson was born at Shieldsboro, Bay St. Louis, Mississippi, August 24, 1816. He was appointed midshipman in the United States Navy in 1830, served in the Mediterranean Squadron, and in 1836 returned home, and graduated from Georgetown College, Kentucky, in 1838. Having served as passed midshipman on the Coast Survey until 1841, he was again on naval sea service until 1844, and subsequently as lieutenant United States Navy, had charge of a hydrographic party on the Coast Survey for four years. In 1850 he took command of a Pacific mail steamship, and continued in that and other private business until 1861. He then returned to the Coast Survey as Inspector of Hydrography, and so remained until he was appointed Superintendent of this work in February, 1874. His death took place at "Brentwood," his residence near Washington, on Monday, August 15th, 1881.

Yours respectfully,

J. E. HILGARD,

In charge of Coast and Geodetic Survey.

The death of Dr. B. H. Coates, the oldest surviving member of the Society, on the 18th instant, aged 83 years and 11 months, was reported.

On motion, Dr. Ruschenberger was appointed to prepare an obituary notice of the deceased.

Prof. Haupt exhibited fragments of terra cotta from the Northern Pacific Railroad crossing of the Little Missouri river, produced by the spontaneous combustion of the Lignite beds between the clay-beds of the bad lands, and extensively employed for ballasting the railroad. Also specimens of silici-

fied wood, one of which may possess archæological value, showing as it does two distinct cuts with an axe; but Prof. Cope expressed the opinion that the chips had been made in the already silicified wood, which is soft enough to cut. At present the locality is high rolling ground destitute of springs, and showing no marks of volcanic action. Most of the standing stumps have diameters varying from one to two feet, but one of them measures nine feet.

A beautiful reduced contour map [in MS.] of the Bald Eagle mountain and Birmingham hills in Blair and Huntingdon counties, Pennsylvania, was exhibited by Mr. Lesley. It represents a recent survey for geological purposes made by Messrs. E. B. and O. B. Harden, Topographical Assistants on the State Survey. The peculiar form of the mountain range made visible by this survey will probably afford the long desired explanation of the structural character of the great faulted anticlinal of Sinking valley.

"Notes on a possible Adite element in the early history of Egypt," were read, in part, by Mr. Lesley; the reading of the remainder was postponed to another meeting.

Pending nominations Nos. 934 to 945 were read, and with the exception of nomination, No. 935 (on motion postponed) were balloted for.

A special report of the Finance Committee on the subject referred to it at the last meeting was read and adopted.

Respecting certain uninvested funds, the Committee on Finance received power to act.

Mr. Fraley reported that he had received and paid over to the Treasurer the quarterly rent from the Michaux Legacy, due October 1st, amounting to $131.18.

The following new members were declared duly elected:

Henry H. Gorringe, Lieutenant-Commander U. S. N.

Jedediah Hotchkiss, Esq., Stanton, Va.

Charles C. Jones, Jr., Esq., Augusta, Georgia.

John Evans, Esq., F.R.S. Nash Mills, Hemel-Hempstead, England, President of the Anthropological Society.

Philip Price Sharpless, Esq., West Chester, Pennsylvania.

Charles A. McCall, M.D., 3941 Chestnut Street, Philadelphia.

C. L. Doolittle, Professor of Mathematics and Astronomy, Lehigh University, Bethlehem, Pennsylvania.

Mansfield Merriman, Professor of Civil Engineering, Lehigh University, Pennsylvania.

Rev. A. Renard, Soc. Jes., Director of the Musée Royal, Brussels.

J. B. Stallo, Esq., Cincinnati, Ohio.

Wm. E. Gladstone, Prime Minister of England.

And the meeting was adjourned.

The Brain of the Cat, Felis domestica. 1. Preliminary Account of the Gross Anatomy. With four plates. By Burt G. Wilder, M.D., Professor of Comparative Anatomy, etc., in Cornell University, and of Physiology in the Medical School of Maine, Member of the Am. Neurological Association, etc.

(*Read before the American Philosophical Society, July 15, 1881.*)

This paper is in four parts:—A. Introduction. B. The macroscopic vocabulary of the brain. C. List of points to be elucidated. D. Explanation of the plates.

A. INTRODUCTION.

The present paper is the first of a series of contributions to the knowledge of the brain of the domestic cat. A second—*A Description of the Cerebral Fissures, together with their Synonymy*—has been nearly ready for a year, and a brief preliminary abstract of it has been published (Wilder *8*),* but it will more properly follow the present general account of the entire brain.

The title of the series is made comprehensive in order that the subject may be discussed from any point of view. I hope, therefore, that others

*This number refers to the list at the end of this paper. In that list, the names of the *authors* are placed in *alphabetical order*. The titles of *separate works* are designated by *letters*, and their order has no significance. The titles of *papers* are *numbered*. In the case of papers published between 1800 and 1873, the numbers correspond to those in the chronological "Catalogue of Scientific Papers," published by the Royal Society of London. In other cases the numbers are only provisional, and are printed in italics.

The references are made as follows: the name of the author is given first, unless the author has been indicated already; then follows the letter or the number by which the title of the work or paper is designated upon the list; if a Roman numeral is given it denotes the number of the volume; and the last number is that of the page. The system of references to a List was followed by me in 1872, in the paper entitled Intermembral Homologies (10), and has been since adopted by others.

may be led to treat certain topics according to the special opportunities which they may enjoy, and that thus, eventually, there may be available for workers in Human, Veterinary and Comparative Anatomy, a complete account of the Gross Anatomy, the Histology, the Development, the Functions, and the Taxonomic Relations of the brain of a common mammal.

That the domestic cat is not only common in most civilized lands, but otherwise well adapted to serve as the basis for work upon other forms, including man, has been urged by Straus-Durckheim (A. pp. xiv and 54), H. S. Williams (A, iii), Mivart (B, ix), and the writer (*2*).

Subsequent experience has abundantly confirmed the views expressed in the paper last named, and has even removed my previous somewhat unfavorable impression respecting the availability of the cat for physiological experimentation.*

That the idea of employing the cat as an introduction to the study of other forms is neither original nor of recent adoption, may be seen from the work of Straus-Durckheim, and from the following passages in my papers :—

"Nearly twenty years ago†, the late Professor Jeffries Wyman, in commenting upon the unsatisfactory nature of some notes of dissections, said : 'Much of this is due to the lack of suitable standards for comparison. The human body is not a suitable standard for the lower vertebrates. The best thing any anatomist can do is to prepare complete accounts of the structure of a few forms, each typical of some large group. The fowl could represent the birds, and the cat the mammals. The cat's anatomy should be done first, because it would serve as an introduction to human anatomy, and thus become an important aid to medical education.'" Wilder, *2*, 5.

Eight years ago, in a paper (11) upon the outer cerebral fissures of certain mammals, I offered the following suggestion :—

"But before any final work can be done in respect to fissures, we need a complete account of the brain of some one mammal, giving its appearance from all sides, sections and dissections of all parts, and demonstrations of the relations which may exist between the fissural pattern and the internal structure; then a full series of figures representing all the stages of development, both of the brain as a whole, and of its parts. On some accounts the fox would be the most useful species, but as it is not to be had in large numbers, and as dogs are ineligible as a standard, from the breed differences as well as from the usual complexity of the fissural pattern, we shall probably find the cat most available for the purpose. Such a work would form a fitting continuation of Straus-Durckheim's magnificent monograph of the Osteology and Myology of that animal. It

* The fiercest cat, provided it can once be induced to enter a bag, is managed almost as easily as a rabbit. Ether and chloroform act quickly and surely, and I have never encountered any serious difficulties, whether in the laboratory or lecture-room, in performing the experiments commonly employed for physiological illustration. Of course, these experiments were all *callisections*, that is, done by the aid of anæsthetics. In my opinion, as elsewhere expressed (*10*), *sentisection* or painful vivisection is rarely necessary or justifiable.

† It was in 1860, now twenty-one years ago.

is one of the tasks which I wish to accomplish, but I trust this will not deter others from undertaking it."

Since the above was written, I have lost no opportunity of accumulating materials for the illustration of the encephalic anatomy of the cat, and the museum of Cornell University now contains more than 220 preparations of the brain of that animal. A few of these are the entire organ, or its undissected halves; the larger number are dissections for the sake of showing certain points in its structure.

At the outset, I hoped to find that, excepting purely histological matters, the structure of the human brain was so fully known as to require little more than the identification and description of the corresponding features in the cat. It was soon apparent, however, that some points of considerable morphological importance were as yet undetermined, or at least presented very unsatisfactorily in the standard works. To the deficiencies or positive errors of the published accounts, was added the difficulty of obtaining examples of the human brain in such a condition as to serve for the determination of doubtful points. After considerable observation and enquiry upon the subject, I am constrained to affirm that, by the ordinary method of extraction, the freshest human brain is so distorted as to be useless excepting for the roughest kind of enquiry, while the average dissecting-room brain is often only fit to be examined with a spoon.

Theoretically, of course, the anatomy of the human brain is to be learned only by the examination of that organ. Practically, however, so great are the difficulties of obtaining, preserving, and dissecting it, that, with most persons, a certain expenditure of time and money upon cats' brains will be more productive than if devoted to the brains of human beings.*

After spending more than twenty years in the study and teaching of anatomy and physiology, aided by the best models and plates, I feel that nearly all my real and substantial knowledge of the brain has been derived from that of the cat. Nor has the time yet come when I can examine a cat's brain for an hour, without correcting some misapprehension, learning something new, or at least gaining some fresh conception respecting the organization or functions of the organ, or its possibilities in the way of variation.

The present paper concerns only the *gross anatomy* of the brain, and even that is treated in only a general way. I fully recognize the great, perhaps the paramount, importance of a complete account of the *histology* of the organ, if only as a basis for the physiological, pathological and

* I have expressed elsewhere (3) the belief that, of all the more easily accessible animals, the cat offers superior advantages for preliminary anatomical work, but of course a large amount of information may be gained from the dissection of any mammal, aside from the mere skill in the use of instruments which comes from their actual employment upon the organs. Hence the following quotation from Solly (A, 93) is given with entire approval:—

"I am sure that whoever will take the trouble to go over this dissection [of the rabbit's brain] once or twice before attempting that of the human brain, will find his path much facilitated by the knowledge and the manual dexterity he will have acquired."

psychological observations which are constantly making in all parts of the world. But, with all deference to the presumed views of the many and indefatigable workers in this finer field, I hold that the more urgent need is for a provisional, at least, *identification and nomenclature of the visible parts.*

I am loth to believe that the authors of some histological contributions are not altogether clear upon the position and relations of the parts concerned; but I apprehend that many readers of such contributions fail to appreciate their excellencies or to recognize their defects from the lack of an adequate familiarity with the gross anatomy of the brain; a lack which seems almost unavoidable so long as the chief dependence is placed upon the text-books, or upon the appearances presented by human brains in the condition in which they commonly find their way to the dissecting-table.

Had a recent writer employed the fresh or well-preserved brain of a cat in place of the (presumably) distorted and semi-decomposed human organ, he never could have published a paper "De la non-existence des trous de Monro;" nor, indeed, does the acceptance of a paper with such a reactionary title indicate that the editors of "Progrès Médicale, Nos. 25, 26," have left the beaten track in this respect.

Whoever will carefully examine the fresh or well-preserved brains of cats need not, unless he prefer to accept authority in place of the evidence of his eyes, either doubt the existence of the "Foramina of Monro," or believe that these openings are primarily for the "transmission of the choroid plexus." Neither need he believe that "the third ventricle communicates with the fifth" in any animal, or at any period of development; that "the great transverse fissure" is a real cleft from the outside of the brain into its "ventricular cavities;" that the "corpora quadrigemina, pineal body, corpora geniculata and thalami are internal parts of the cerebrum;" or that, in the cat at least, the thalami enter, in the slightest degree, into the formation of "the floor of the lateral ventricles."

With the view of aiding in the correction of some of such current misapprehensions, and paving the way for more sound and enduring work in other directions, the present paper is purely morphological, and all teleological considerations have been excluded.

Moreover, as has been said already, only a general view of the organ is here given. Each part of the brain requires more or less extended monographic treatment. Not only should its average or usual form, structure, and connections be determined, but its variations should be noted, and correlated with known differences in respect to the age, sex, breed, color and disposition. Anomalies also should be recorded. Of course, such striking cases as the absence of the callosum, reported by the writer in 1879 (*13*) would be at once remarked; but in many other respects we are as yet unaware what is the real normal condition, and are hence unable to determine the extent of departure therefrom. The small size of the cat's brain and the ease with which large numbers may be obtained and preserved, render it peculiarly adapted for this line of enquiry.

It is generally admitted that the brain might be of use in the determination of zoölogical affinities. That it is really so seldom employed for this purpose, excepting as furnishing merely corroboratory evidence, is largely due to the vagueness of our information, which prevents exact comparisons. Now the Carnivora in general, and the Felidæ in particular, form very compact and well-defined groups; hence the careful comparison of the parts of the cat's brain with the homologous parts in other members of the family and order should not only be comparatively easy, but also afford some clues to the functions of the parts, as well as furnish a basis for taxonomic considerations.

It would probably be difficult to estimate the influence, upon both physiology and systematic zoölogy, of the sum of knowledge which may be available when the brain has received an amount of time, labor and thought equal to that which has been devoted to the skull.

Considering the abundance of the domestic cat in most parts of the world where anatomy is cultivated, very little use seems to have been made of its brain. In several papers (Owen, 35), Krueg (*2*), Benedikt (*1* and *2*), Pansch (*1*), the cerebral fissures are more or less fully discussed; but I am not acquainted with any special paper on the entire organ, and the only figures of the structure known to me are the following: The mesal surface is shown by Leuret et Gratiolet (A, pl. v, fig. 3); the procœliæ (ventriculi laterales) are shown by Gegenbaur (A, 508, fig. 286); and the dorsal and ventral surfaces are partly seen in connection with the nerves in Bourgery and Jacob (A, pl. xvi).

The sheep's brain seems to have been selected by Foster and Langley (A), and by Morrell (A), partly, at least, on account of the ease with which the head may be procured, thus avoiding the killing of an animal for the sake of the brain. But cats are so plenty, and so readily killed by chloroform, that no objection need exist upon that score, and the brain is removed, preserved and dissected much more conveniently than that of the sheep.*

The small size of some of the parts of the cat's brain is an objection, no doubt; but this is atoned for by the number of preparations one may make and keep, and by the ease with which the entire organ may be held or placed in any position so as to obtain the best light without the danger—which is ever present with larger brains—of tearing by its own weight.

B. THE MACROSCOPIC VOCABULARY OF THE BRAIN.

In a recent paper (*9*), I have presented somewhat in detail both the grounds for attempting a Revision of Anatomical Nomenclature, and the results of that revision.

With a slight rearrangement, and some unimportant verbal alterations, the following paragraphs remain as there published (pp. 123, 137), and

* For a detailed account of the methods of preparing the cat's brain, see my paper in "Science" (*11*).

embody a brief statement of "the objects of the present revision, the considerations upon which it is based, and the methods which have been pursued :"

"To facilitate the acquisition and communication of accurate anatomical knowledge, by rendering the vocabulary equally applicable to all vertebrates, and equally intelligible to all nations.

"That the convenience and preferences of all existing anatomists should be held of little moment as compared with the advantages which reform may ensure to the vastly more numerous anatomical workers of the future.

"That the test of the accuracy and completeness of a description is, not that it may assist, but that it cannot mislead.

"That *brevity* is an especially desirable characteristic of such names as are most frequently employed.

"To include in this vocabulary, so far as practicable, only such terms as are brief, simple, significant, of classical origin and capable of inflection.

"To propose as few changes as possible, and to introduce new names only for parts apparently unknown or unnamed before (*e. g., crista fornicis*), or in the place of semi-descriptive appellations undesirably long or incapable of inflection, as *e. g., cimbia* for *tractus transversus pedunculi, porta* for *foramen Monroi*.

"When a part is known by a descriptive phrase, to select therefrom some characteristic word as the technical designation ; *e. g., iter* (*a tertio ad ventriculum quartum*).

"When two or more parts are similar, or have similar relations, to distinguish them by joining to some common title already in use prefixes indicative of their relative positions ; *e. g., postgeniculatum, prægeniculatum*.

"To shorten the names of several parts by omitting the word *corpus*, and using the neuter adjective as a substantive.

"To discard terms which indicate *size*, those which refer to the *natural attitude* of man or animals, most *vernacular* names, and all names of the reproductive organs which have been applied needlessly to other parts of the body.

"To keep modern usage, and the rules of classical etymology constantly in mind, but not to be hindered thereby from the employment or even the formation of terms which are eminently desirable from the practical standpoint."

At my request, the publisher of "Science" kindly sent copies of the two numbers containing the article to leading scientific, medical and literary journals, and to about 22 naturalists or physicians who make more or less use of anatomical terms in their writings. There has been scarcely time for any extended criticism of the proposed changes, but as the article contained a very distinct request for suggestions, I am disposed to infer that anatomists are at least willing to let the new terms have a fair trial in the present paper, the preparation of which was announced at the head of the article.

The following are the only published comments upon the subject, which have come to my notice :—*

In *The Nation* for April 12, 1881, is a brief notice of the article, evidently

* Since this was written, The Journal of Nervous and Mental Disease for July, 1881 (652-661), has reprinted from the paper (*9*) the List of names of encephalic parts, and regards the new nomenclature as supported by "rather satisfactory arguments." See also p. 562 of this paper.

by an anatomical teacher, from which I quote the following: "There is certainly ample room for it [the reform proposed], but one cannot help thinking that in his desire for set names, Professor Wilder approaches pedantry." In view of what might have been expected from so critical a journal, I am disposed to feel more encouraged by the admission than disheartened by the objection.

Dr. Oliver Wendell Holmes wrote me the following letter upon the subject, which, with his permission, was printed in "Science" for June 4, and is here, in part, reproduced:—

BOSTON, May 30, 1881.

DEAR DR. WILDER:—I have read carefully your paper on Nomenclature. I entirely approve of it as an attempt—an attempt which I hope will be partially successful, for no such sweeping change is, I think, ever adopted as a whole. But I am struck with the reasonableness of the system of changes you propose, and the fitness of many of the special terms you have suggested.

The last thing an old teacher wants is, as you know full well, a new set of names for a familiar set of objects. It is hard teaching old professors new tricks. So my approbation of your attempt is a *sic vos non vobis* case so far as I am concerned. * * *

What you have to do is to keep agitating the subject, to go on training your students to the new terms—some of which you or others will doubtless see reasons for changing—to improve as far as possible, fill up blanks, perhaps get up a small Manual in which the new terms shall be practically applied, and have faith that sooner or later the best part of your innovations will find their way into scientific use.

* * * The plan is an excellent one—it is a new garment which will fit Science well, if that capricious and fantastic and old-fashioned-dressing lady can only be induced to try it on.

Always very truly yours,

O. W. HOLMES.

Dr. Holmes's literary authority, as well as the fact, perhaps less generally known, that for 33 years he has been the Professor of Anatomy in the Medical School of Harvard University, will give great weight to his approbation of my undertaking.

In Science for April 29, 1881, Dr. E. C. Spitzka of New York, well-known as an indefatigable worker in encephalic anatomy and histology, published (7) a letter to the Editor respecting my article. Dr. Spitzka generously puts aside the natural feeling of disappointment that a task which he had contemplated for several years should be, however imperfectly, performed by another, and, together with valuable practicable suggestions upon several important points, comments as follows upon the general subject:—

"It is with mingled pleasure and profit that I have read the very suggestive paper on Cerebral Nomenclature contributed to your latest issues by Prof. Wilder. Some of the suggestions which he has made have been

latent in my own mind for years, but I have lacked the courage to bring them before my colleagues. Now that he has broken ground, those who prefer a rational nomenclature to one which like the *present* reigning one, is based upon erroneous principles, or rather on no principles at all, will be rejoiced at the precedent thus set for innovations. As Prof. Wilder has invited criticism, I take the opportunity of offering the following remarks upon the leading points of his papers, in so far as they refer to the brain alone.

"1. The principles announced are such as zoötomists and anatomists generally will agree with, to the fullest extent. * * * I have no hesitation in saying that the labor of the anatomical student will be diminished fully one-half when this nomenclature shall have been definitely adopted. * * * In Germany the older system has gone out of use almost entirely, and not the least charm about the works of Henle, Schwalbe, Forel and Gudden, is the fact that these authors have more or less done away with the ambiguous terms once rampant.

"3. In proceeding to comment on some of the terms proposed by Prof. Wilder, I wish it to be distinctly understood that I do so merely tentatively and to promote discussion; in so doing I feel certain that I am carrying out that writer's wish. It is but just to state that the majority of the terms cannot be discussed—they are perfection and simplicity combined."

I think Dr. Spitzka does himself scant justice in ascribing his non-presentation of the subject to "a lack of courage." But I can well understand that the demands of an active practice have forced him to defer from time to time the somewhat onerous task of putting his material into shape for publication.*

In the following discussion of the macroscopic vocabulary of the brain, I have transcribed freely from the article above named, introducing such modifications as have since appeared to me desirable.

The terms employed by anatomists form two divisions: those which indicate the *position* or *direction* of organs, and those by which the organs themselves are designated. Since, also, writers have usually treated of them separately, it will be convenient here to consider anatomical *toponomy* and *organonomy* under distinct headings.

Terms of Position and Direction—Toponomy.

Dr. Barclay's volume had especial reference to this division of the subject, and its key-note is struck in the following paragraph (A, 5):

"The vague ambiguity of such terms as superior, inferior, anterior, posterior, &c., must have been felt and acknowledged by every person the least versant with anatomical description."

Dunglison admits (A, 61) that "Great confusion has prevailed with anatomists in the use of the terms before, behind, &c." Dr. Spitzka has forcibly stated (*1*, 75, note 1) the objections to the use of anterior, &c., and their unsuitability is tacitly conceded in the employment of other terms by

*Since this paper was presented, Dr. Spitzka has published an able contribution (*10*) to our knowledge of the metencephalon, in which the toponomical terms herein suggested are employed.

several writers who do not explicitly condemn the current toponomy: Gegenbaur (A, 491), Mivart (A, 69), Cleland (*1*, 170), Rolleston (B, 33, note), &c.

Finally, the need of a radical change of base has been proclaimed in one of the very strongholds of anthropotomy:—

"Now that the more extended study of comparative anatomy and embryonic development is largely applied to the elucidation of the human structure, it is very desirable that descriptive terms should be sought which may, without ambiguity, indicate position and relation in the organism at once in man and animals. Such terms as cephalic and caudal, dorsal and ventral, &c., are of this kind, and ought, whenever this may be done consistently with sufficient clearness of description, to take the place of those which are only applicable to the peculiar attitude of the human body."—Quain, A, I, 6.

This is certainly explicit as to the principle involved, and it is to be hoped that later editions of this standard Human Anatomy may display its practical application to the body of the work.

How slender is the justification for retaining a toponomical vocabulary based upon the relations of organisms to the surface of the earth, appears more fully when we reflect that the assumed standard, for the higher vertebrates at least, is man in his natural erect attitude; yet that both man and animals are more often examined and compared with the *back downward*, this being an attitude truly characteristic of only that infrequent "subject," the sloth.

As a single illustration of the logical inconsistencies into which we are led by the use of the current toponomy, take the series of possible designations of the direction of some vertebral spinous process which projects toward the skin of the back at, or approximately at, a right angle with the myelon. With man the direction in which it points is *posterior*, but with a cat it is *superior*, while with an ape or a bird it is somewhere between the two; with all four, when on the dissecting table, it would be usually *inferior*. Finally, with a flounder the corresponding direction would be *horizontal* or *sidewise*.

In short, to designate the locations of organs by the relations of animals to the surface of the earth, which relation differs in nearly allied forms, and varies with the same individual according to circumstances, is as far from philosophical as it would be to define the place of a house or a tree by reference to the planet Jupiter, or to assume that mankind naturally face the rising sun, and hence to designate our right and left as the south and north sides of the body.

The present tendency of accurate anatomical description is to refer the position or direction of all parts and organs to an imaginary plane dividing the body into approximately equal right and left halves; hence it is desirable to designate this middle plane, or any line contained therein, by a word which is at once significant, short, and capable of inflection. Dr. Barclay proposed *mesion*, and *mesial* has been generally used; but would

it not better to adopt the very term employed by the Greeks to signify the middle, *meson*, τό μέσον, equivalent to the more ponderous Latin *meditullium*? The corresponding adjective is *mesal*, and the adverb *mesad*, while in combination it becomes *meso*.

The following general terms were also proposed by Barclay, and have been more or less systematically employed by Owen, Huxley and others: *Dorsal, ventral, dextral, sinistral, lateral*, with the corresponding adverbial forms *dorsad*,* etc. Should the alleged correspondence of the ventral region of the Vertebrate with the tergal region of the Arthropod prove to be one of true homology, it may be desirable in time to discard *dorsal* and *ventral* for more suitable terms, but for the present, if on practical grounds alone, it seems well to retain them.

Barclay proposed *atlantal* and *sacral* for the designation of the position of parts lying toward the head or the tail, in reference to an imaginary plane dividing the trunk at the middle of its length. But these terms were not applicable to parts beyond the atlas and the sacrum, so that new words were applied to the regions of the head. Perhaps this needless complication has hindered the general adoption of Barclay's nomenclature nothwithstanding its many admirable features. At any rate, *cephalic* and *caudal* are much more acceptable terms, and are practically unobjectionable, although certain theoretical difficulties readily suggest themselves.

Proximal and *distal*, *central* and *peripheral* are in common use, and the general employment of their inflections and derivatives is only a question of time. *Proximal* and *distal* seem to be more applicable to the limbs and their segments, while *central* and *peripheral* may be employed for vessels and nerves.

Ental, and *ectal* were proposed (*9*) as substitutes for the more or less ambiguous words *inner* and *outer*, *interior* and *exterior*, *deep* and *superficial*, *profound* and *sublime*. Derived respectively from ἐντός and ἐκτός their significance is obvious, while their brevity and capacity for inflection will probably commend them to accurate working anatomists.

The Names of the Parts—Organonomy.

Abbreviations of the more general names of encephalic parts.

Ar.—Area.	F.—Fissura.	Px.—Plexus.
C.—Cœlia.	Fm.—Foramen.	R.—Recessus.
Clm.—Columna.	Fn.—Funiculus (root-let).	Rx.—Radix.
Cn.—Canalis.	Fs.—Fossa.	Sl.—Sulcus.
Cp.—Corpus.	Inc.—Incisura.	Spt.—Septum.
Cr.—Crus.	L.—Lobus.	T.—Tuber.
Crs.—Crista.	Ll.—Lobulus.	Tr.—Tractus.
Cs.—Commissura.	Pt.—Portio.	Tl.—Tela.
Em.—Eminentia.		

*In his recent paper (*2*) on the Evolution of Mammals, as printed in "Nature," Jan. 6, 1881, p. 228, Huxley uses the term *dorsad*.

ABRIDGED SYNONYMY OF THE CEREBRAL FISSURES.

Abbrev.	*Flower*, 1869, 28. *Leuret*, 1839, A. *Huxley*, 1861, 70; 1872, A.	*Owen*, 1868, A.	*Wilder*, 1873, 10.	*Krueg*, 1880, 2.	*Adopted in the present paper.*	
a.		Ant. branch of ectosylvian	Ant. upright of ectoslyvian	Anterior.	Anterior.	a.
an				Ansata.	Ansata.	an.
cf.		Part of medilateral.	Part of medilateral.	Confinis	Confinis.	cf.
cl.		Callosal.			Callosalis.	cl.
cor.		Coronal.	Coronal	Coronalis.	Coronalis.	cor.
cr.	Crucial	Frontal.	Frontal	Cruciata	Cruciata.	cr.
dg.				Diagonalis.	Diagonalis	dg.
fm.					Fimbriæ.	fm.
fl.		Part of falcial.		Genualis	Falcialis	fl.
hmp.	Hippocampal. Dentate, *Huxley*, 1861.	Hippocampal.		Hippocampi.	Hypocampæ	hmp.
in					Intermedia	in.
l.		Lateral	Lateral.	Lateralis.	Lateralis	l.
in					Lunata	ln.
mi.		Part of medilateral	Part of medilateral.	Medilateralis	Medilateralis.	mi.
mr.		Marginal.		Suprasplenialis	Marginalis	mr.
ol.			Ectorhinal.	Olfactoria.	Olfactoria.	ol.
p.		Post. branch of ectosylvian	Post. upright of ectosylvian.	Postica.	Postica.	p.
per.				Postcruciata.	Postcruciata	per.
pmr				Postsplenialis	Postmarginalis.	pmr.
prd					Postradicalis.	prd.
prh.		Part of ectorhinal	Part of rhinal.	Rhinalis posterior.	Postrhinalis	prh.
prrd					Præradicalis.	prrd.
ps		Postsylvian.	Part of supersylvian	Suprasylvian poster-	Postsylviana.	ps.
rh		Part of ectorhinal	Part of rhinal	Rhinalis. [ior.	Rhinalis	rh.
s.	Sylvian	Sylvian.	Sylvian.	Sylvii.	Sylviana	s.
sfl		Part of falcial		Rostralis.	Subfalcialis.	sfl.
sp	Callosomarginalis (Flow. and Huxley).	Supercallosal.		Splenialis	Splenialis.	sp.
so	Supraorbital (Flow.).		Presylvian.	Præsylvii	Superorbitalis	so.
ss.		Supersylvian.	Postsylvian & supersylvian.	Suprasylvii	Supersylviana.	ss.

ABBREVIATIONS OF THE CRANIAL NERVES. (See fig. 3.)

For convenient comparison, the numerals applied by Sœmmering are prefixed to the proper abbreviations.

vi. *abd.*—Abducens.
xi. *ac.*—Accessorius (spinalis).
viii. *au.*—Auditorius. (Portio mollis.)
vii. *f.*—Facialis. (Portio dura.)
ix. *gph.*—Glossopharyngeus.
xii. *hg.*—Hypoglossus.
iii. *ocm.*—Oculomotorius. Motor communis.
i. *ol.*—Olfactorius.
ii. *op.*—Opticus.
iv. *tr.*—Trochlearis. "Patheticus."
v. *trg.*—Trigeminus. Trifacialis.
x. *v.*—Vagus. Pneumogastricus. Par vagum.

LIST OF THE PARTS OF THE CAT'S BRAIN WHICH ARE VISIBLE TO THE UNAIDED EYE.

To avoid repetition, this list is accompanied by the abbreviations which are used upon the plates, and, for convenience of reference, the names are arranged in the alphabetical order of the abbreviations. Only the abbreviations of *general* names are capitalized. The numbers following the names indicate the figures upon which the parts are shown, or, in a few cases, the pages on which they are mentioned.

Most of the names are those in common use, with the omission of superfluous elements like *corpus*, and the genitives of the names of more comprehensive parts. Most of the apparently new names will be found to be old acquaintances under such thin disguises as *translation*, *transposition*, *abridgment*, and the *substitution of prefixes* for qualifying words. In a few cases the old names, are wholly discarded for briefer new ones. Most of the new names, however, refer to parts apparently unobserved hitherto (*e. g.*, *crista*, *carina*, *delta*), or to parts which—although probably observed—seem not to have been regarded as needing a special designation (*e. g.*, *aula*, *quadrans*, *pero*).

So much of each name as immediately follows the abbreviation, is regarded as a sufficient designation of the part under ordinary circumstances; sometimes it may be desirable to add the words in parenthesis.

a.—Aula. The cavity of the primitive prosencephalon, or Lobus communis. 3, 13, 16. See p. 540.
abn.—Albicans (Corpus). 3, 4, 11.
alb.—Alba (Substantia). White matter. 13, 14, 20.
apx.—Auliplexus. Not distinctly shown. See p. 542.
arb. vt.—Arbor vitæ (cerebelli). 4.
Ar. cr.—Area cruralis. 3, 11.
Ar. icr.—Area intercruralis. 3, 11.
Ar. el.—Area elliptica. 3.

Ar. ov.—Area ovalis. 3.
Ar. ppn.—Area postpontilis. 3.
Ar. prch.—Area præchiasmatica. 3.
Ar. spt.—Area septalis. 4, 16.

ca.—Carina (fornicis). Not shown, see p. 556.
cb. or *hem.*—Cerebrum; prosencephalon; hemisphæræ. 1, 2, etc.
cbl.—Cerebellum. 1, 2, 12, 15.
cd. s.—Cauda striati. See p. 542.
cel. m.—Cella media (procœliæ). 15.
ch.—Chiasma (NN. opticorum). 3, 4, 5, 11, 16.
cin.—Cinerea (Substantia). Gray matter. 14, 20.
cl.—Callosum (Corpus). 4, 13, 15, 16, 17, 20.
clc.—Calcar. Hippocampus minor. Not in the cat.
clv.—Clava. 12.
Clm. d.—Columna dorsalis myelonis. Posterior white column of the spinal cord. 1.
Clm. f.—Columna fornicis. 4, 10, 13, 14, 16.
Clm. l.—Clm. lateralis myelonis. 1, 3.
Clm. v.—Clm. ventralis myelonis. 3.
cmb.—Cimbia. Tractus transversus pedunculi. 3, 8, 9, 11.
cn.—Conarium. Corpus pineale. 7, 10. See p. 562.
Cn. ce.—Canalis centralis (myelonis). 4.
Cr. cb.—Crus cerebri. 2, 4, 9, 11, 18, 19.
Cr. ol.—Crus olfactorium. 4, 5.
Crs. f.—Crista (fornicis). 4, 14, 16, 20. (See Wilder, 7.)
Cs. f.—Commissura fornicis. 14.
Cs. h.—Commissura habenarum. 4, 6.

d.—Dura (mater). Not shown.
dc.—Diacœlia. Ventriculus tertius. 4, 6, 7, 16. See p. 539.
den.—Diencephalon, interbrain. 7, 9, 10.
dlt.—Delta (fornicis). 10, 14.
dpx.—Diaplexus. Plexus choroideus ventriculi tertii.—4, 16.
dtl.—Diatela. Roof of diacœlia.

Em. au.—Eminentia auditoria. 2, 3.
end.—Endyma ependyma. The lining membrane of the cœliæ.
epc.—Epicœlia. Ventriculus cerebelli. 4.
epen.—Epencephalon. Hind brain. 4.
f.—Fornix. 14, 15, 16, 17, 19, 20.
F.—Fissura. See list of cerebral fissures, p. 534.
F. dl.—Fissura dorsilateralis (myelonis). Postero-lateral fissure of the spinal cord. 1.
F. dms.—Fissura dorsimesalis (myelonis). 1.
F. vl.—F. ventrilateralis (myelonis). 3.
F. vms.—F. ventrimesalis (myelonis). 3.
Fm. cc.—Foramen cæcum. 3.

Fm. cn.—Foramen conarii. 6.
Fm. inf.—Foramen infundibuli. 6.
fmb.—Fimbria. Corpus fimbriatum. 14, 17.
fscl.—Fasciola. Fascia dentata and fasciola. 14, 17.
g.—Genu (callosi). 4, 17.
h.—Habena. Habenula ; pedunculus pinealis. 4, 7, 16.
hem.—Hæmisphæra. Hemicerebrum. 1, 2, 3, 4, etc.
hmp.—Hypocampa. Hippocampus major. 14, 15, 18, 19.
hph.—Hypophysis. Corpus pituitarium. 3, 4. See p. 562.
Inc. hmp.—Incisura hypocampæ. 11.
inf.—Infundibulum. 3.
ins.—Insula. Island of Reil. Not distinct in the cat. See p. 543.
it.—Iter (a tertio ad quartum ventriculum). Mesocœlia, *msc.* 4, 8.
L. l.—Lobus lateralis (cerebelli). 1, 2, 15.
L. ol.—Lobus olfactorius. 1, 2, 15, 17, 18.
L. tmp.—Lobus temporalis (hemisphæræ). 2.
Ll. ap.—Lobulus appendicularis (cerebelli). 2, 3.
Ll. hmp.—Lobulus hypocampæ. Ll. mastoideus. 2, 14, 17.
lm. alb.—Limes alba (radicis lateralis cruris olfactorii). 2, 5.
lm. cin.—Limes cinerea. 2, 5.
lq. c.—Liquor cœliarum. Liquor ventriculi.
ly.—Lyra (fornicis). Psalterium. 14. See p. 543.
mcs.—Medicommissura. Commissura mollis. 4, 16.
mcu.—Medicornu (procœliæ). Cornu temporale. Cornu descendens. 11, 14, 18, 19.
mpd.—Medipedunculus (cerebelli). Crus ad pontem. 8.
msc.—Mesocœlia. Iter. Ventriculus loborum opticorum mesalis. 4, 8.
msen.—Mesencephalon. Midbrain. Lobi optici, etc. 7, 9.
mtc.—Metacœlia. Ventriculus quartus, less the epicœlia. 4.
mten.—Metencephalon. Medulla oblongata. After-brain. 1, 2, 4, 12.
mtpx.—Metaplexus. Plexus choroideus medullæ. 3, 12.
mttl.—Metatela. Roof of metacœlia. 4, 12.
my.—Myelon. Spinal cord. 1, 2.
ob.—Obex. Not identified in the cat.
olv.—Oliva. Corpus olivarium. Not identified in the cat.
op.—Opticus (Lobus). Cephalic optic lobe; natis cerebri. 4, 7, 9, 18, 19.
p.—Porta (Monroi). Foramen Monroi. 14, 16, 18, 19. See p. 540.
pi.—Pia (mater). Not shown. See p. 543.
pcs.—Postcommissura. Commissura posterior. 4.
pgn.—Postgeniculatum, (Corpus). Corpus geniculatum internum. 7, 8, 9, 10.
po. ol.—Pero olfactorius. 16.
pop.—Postopticus (Lobus). Caudal optic lobe ; testis cerebri. 4, 7, 8, 9, 18, 19.

pn.—Pons (Varolii). 2, 3, 4, 9, 11.
ppf.—Postperforatus (Locus). 3, 4, 11.
ppx.—portiplexus. 18.
prc.—Procœlia. Cœlia prosencephali; ventriculus lateralis. 15, 16, 18, 19.
prcs.—Præcommisura. Commissura anterior. 4, 14, 16.
prcu.—Præcornu (procœliæ). Cornu anterius. 13, 15, 16, 18, 19.
pren.—Prosencephalon. Cerebrum. Hemisphæræ.
prgn.—Prægeniculatum. Corpus geniculatum externum. 7, 8, 9.
prpf.—Præperforatus. (Locus). Locus perforatus anterior. 3, 4, 11.
prpx.—Proplexus. Plexus procœliæ. 15, 18.
ps. ol.—Pes olfactorius. 16.
Pt. d.—Portio depressa (præperforati). 3, 11.
Pt. dien.—Portio diencephalica (cruris cerebri). 11.
Pt. msen.—Portio mesencephalica (cruris cerebri). 11.
Pt. p.—Portio prominens (præperforati). 3, 4, 11.
py.—Pyramis (metencephali). Pyramis anterior. 3, 4.
psc.—Pseudocœlia. Ventriculus septi lucidi; fifth ventricle. Not in the cat. See p. 549.
q.—Quadrans (cruris.) 11.

r.—Rima. Fissure of Bichat. 14, 17.
R. a.—Recessus aulæ. 14.
R. op.—Recessus opticus. 4, 11, 16.
R. prpn.—Recessus præpontilis. 4.
Rg. a.—Regio aulica. The complex region about the aula.
rhc.—Rhinocœlia. Ventriculus olfactorius. 16.
rhen.—Rhinencephalon. Lobi olfactorii. 1, etc.
rm.—Rostrum (callosi). 4.
rp.—Ripa. 14.
Rx. in.—(Cruris olfactorii). Not distinct in the cat. See p. 548.
Rx. l.—Radix lateralis. 3.
Rx. mt.—Radix motoria (Nervi trigemini). 3.
Rx. ms.—Radix mesalis (Cruris olfactorii). 3.
Rx. sn.—Radix sensoria (Nervi trigemini). 3.

s.—Striatum (Corpus). 13, 15, 16.
Sl. h.—Sulcus habenæ. 7.
Sl. ic. l.—Sulcus intercruralis lateralis. 11.
Sl. ic. ms.—Sulcus intercruralis mesalis. 11.
Sl. li.—Sulcus limitans. 13.
Sl. trd.—Sulcus triradiatus. 11.
sp.—Splenium (callosi). 4, 6, 14, 17.
Spt. lu.—Septum lucidum. 16, 19.

t.—Terma. Lamina terminalis. 4, 16. See pp. 541, 544.
T. cin.—Tuber cinereum. 3, 4, 11.
th.—Thalamus (Nervorum opticorum). 7, 9, 10, 13.

Tr. op.—Tractus opticus. 3, 11, 14, 19.
Tr. prh.—Tractus postrhinalis. 3.
tz.—Trapezium. 2, 3.

vl.—Velum (interpositum). Not shown. See p. 544.
vm.—Vermis (cerebelli). 1, 2, 15.
vv.—Valvula (cerebelli). 4.

A few of the terms included in the foregoing list need more extended mention.

The encephalic segments.—It is often convenient, and always more philosophical, to regard the brain as composed of a series of *segments* or *divisions*, each consisting of a cavity, with its sides, floor, and roof variously thickened, convoluted, or otherwise modified. So far as is known, the anatomical divisions most conveniently made correspond essentially with the series of embryonic vesicles.

To these divisions, the German anatomists, following, I believe, Von Baer, apply the names *vorderhirn*, *zwischenhirn*, *mittelhirn*, *hinterhirn*, and *nachhirn*, which are commonly rendered in English by *forebrain*, *'tweenbrain*, *midbrain*, *hindbrain*, and *afterbrain*.

In converting these vernacular terms into technical, anatomists have generally recognized the practical advantage of regarding the *Lobi olfactorii* as a segment apart from the cerebral hemispheres, under the name of *rhinencephalon*. The hemispheres, including the *striati*, etc., constitute the *prosencephalon*, and the *Lobi optici*, with the corresponding portion of the *Crura cerebri*, form the *mesencephalon*. So far, all agree. But the region including the thalami, between the prosen. and the mesen. has been variously called *deutencephalon*, *thalamencephalon*, and *diencephalon*. Unable to ascertain which has priority, I select the last as the shortest and most applicable.

Upon the names of the remaining parts of the brain there is more serious divergence of usage among writers. Owen (A, I, 293) calls it all *epencephalon;* but Huxley applies (A, 60) that name to the pons and cerebellum as a division separate from the medulla, which he calls *myelencephalon*, notwithstanding this term had been previously proposed by Owen (A, I, 268) for the entire "cerebro-spinal axis." In this, Huxley is followed by the English editor of "Gegenbaur" (A, xiii) notwithstanding his admission that a different nomenclature had been previously published in Quain (A, II, 755). The editors of "Quain" recognize the two divisions, and apply *epencephalon* to the pons and cerebellum, giving to the medulla proper the name *metencephalon*. On all accounts, this seems to me the best arrangement of terms for the encephalic segments, and is followed in the present paper.

The cœliæ, or encephalic "ventricles."—The incongruity of the anthropotomical designations of the encephalic cavities has been pointed out by Owen (A, I, 294, note), and the writer (*9*, 125).

The *canalis centralis* expands into a cavity which, although the first of

the series, is called the *fourth* ventricle. The more or less distinct cavities corresponding to the cerebellum and the Lobi optici are not called ventricles at all, and the *third* is between the thalami. The two "lateral" ventricles are rarely mentioned as the *first* and *second*, but since the numbers must be understood in order to account for the *third* and *fourth*, the student desires, in vain, to know which is the first and which the second. In point of fact, if the enumeration is begun at the cephalic end of the series, the lateral ventricles are the third and fourth, since there are well-developed ventricles in the *Lobi olfactorii*. Finally, a "*fifth* ventricle" is mentioned, which is not only at the greatest distance from the fourth, but has no normal connection with the other ventricles, and is, in fact, no part of the series.

In view of all this, the task of describing to students the highways and by-ways of the brain—which should be most attractive because therein is most clearly manifested the ideal arrangement of the organ—is one from which I shrink as from any other kind of solemn nonsense. To my mind, indeed, rather than go on as we have been going, it would be at once more philosophical and more intelligible to adopt the simple vocal device employed by Straus-Durckheim for the designation of the Ossa metatarsalia—"padion, pedion, pidion, podion, pudion"—and to re-christen the ventricles by, for instance, the names *pran*, *pren*, *prin*, *pron*, and *prun*.

Fortunately, however, another alternative is presented. Assuming that the terms *rhinencephalon*, *prosencephalon*, *diencephalon*, *mesencephalon*, *epencephalon* and *metencephalon* are to be retained, and that they are to be learned by successive generations of students, why should we not transfer the distinctive prefixes to the Greek word for ventricle, *κοιλία*, *cœlia?* This would give us *rhinocœlia*, *procœlia*, *diacœlia*, *mesocœlia*, *epicœlia*, and *metacœlia*.

These terms are capable of inflection, and the longest of them is no longer than the Latin *ventriculus*, which requires a prefix or qualifying word. These prefixes may be also employed for the designation of the membraneous roofs of the "third" and "fourth" ventricles, and the plexuses of these and the lateral ventricles. Thus we should have *metatela* and *metaplexus*, *diatela* and *diaplexus*, *proplexus*, *portiplexus*, and *auliplexus*. Two or more "ventricles" would be spoken of as *cœliæ*, while the "fifth ventricle," which is really no part of the series, may well be called *pseudocœlia*.

Aula.—I hope, before long, to justify more fully the proposition already made (Wilder, *5* and *9*), to consider the cephalic portion of the "third ventricle" between the *portæ* (Foramina Monroi), as a morphologically independent cavity under the name of *aula*.

Porta.—This is proposed as a convenient substitute for the phrase "Foramen Monroi." If the two orifices leading, respectively, from the two procœliæ ("lateral ventricles"), into the aula, and so communicating with the entire mesal series of cœliæ, were seldom employed, or even as frequently as "Foramen Magendie," there might be less call for a change of name; but, according to my view of the best method of studying the

brain, these slight orifices, which are but rarely demonstrated, and have never been, so far as I know, accurately figured, have a real and great morphical value, and should be frequently named; hence the desirability of a short term capable of inflection. Since there is no other encephalic *porta*, the single word is sufficient; but *Monroi* may be regarded as belonging thereto, in memory of the description of the parts by A. Monro *secundus* (A). See my paper (*3*).

Medicornu, etc.—In place of the terms *Cornu descendens*, etc., I have suggested that the three prolongations of the procœlia into the *Lobi temporalis, frontalis*, and *occipitalis* respectively, should be called *medicornu, præcornu*, and *postcornu*. The latter does not exist in the cat.

Rima.—This brief name is proposed as a substitute for the phrase *"rima transversa cerebri magna,"* and its various classical or vernacular equivalents. That, in the cat, the connection of the two borders of the rima is complete, and capable of resisting a considerable pressure of air, alcohol or plaster, has been repeatedly demonstrated by me since the 25th of November, 1876. But the proper nervous tissue is interrupted from the dorsal border of the porta to near the tip of the medicornu, and, in so heavy a brain as that of man, the membraneous connections are readily torn during the extraction or manipulation of the organ; see my paper, *9*, 136.

Proterma.—prtr.—The primitive *lamina terminalis* or *l. cinerea*. *Terma embryonis*. My reason for suggesting different terms for the adult and embryonic terminal plates, is that, as now understood, the latter includes not only the *lamina cinerea* of anthropotomy, but also the parts afterward differentiated to form the *Columnæ fornicis*, and the *præcommissura*, with perhaps some other parts of the *fornix*.

Hypocampa.—In the paper on Nomenclature (*9*, 125) I stated that this term is employed by Vicq D'Azyr (A) in the descriptions of the plates, although the more common form *hippocampus* occurs in the "List of anatomical terms," in the same work. At that time, I had only seen the passages in the description of pl. vii, fig. 1 and 3; pl. viii, fig. 2; on p. 61, and elsewhere, where the French form *hypocampe* is used. I have since found several passages, as the descriptions of pl. vi, note, and plate viii, fig. 2, where the Latin forms *hypocampus* and *hypocampi* are given.

Vicq D'Azyr does not discuss the etymology of the term, but says (A, p. 61), the "grande hypocampe" was first mentioned by Arantius and Varolius, whose works are not now accessible to me. Even Hyrtl (A, 180), does not seem aware of the use of the word by Vicq D'Azyr, and all other writers, so far as I know, make it *hippocapmus*. There is no such word as *κάμπος*, and, if the original orthography cannot be ascertained, *hypocampa* is to be preferred on etymological grounds; the ridges known as *hippocampus major* and *h. minor* bear no obvious resemblance to the fish known to the ancients as *ἱπποκάμπος* and *hippocampus*, but the larger of the two, which probably first received the name, does certainly present a most notable *downward curvature*, such as the Greeks might have designated by *ὑποκαμπή*.

C. A LIST OF SOME POINTS TO BE ELUCIDATED.

No part of the cat's brain is thoroughly or sufficiently understood, and all parts need monographic treatment. The following points, therefore, are selected because the deficiencies in our knowledge of them have been most distinctly impressed upon me.

Albicans.—abn.—Have the *albicantia* the same relation to the Columnæ fornicis which is said to exist in the human brain? What morphical or telical significance has their degree of separation from one another?

Area elliptica.—Ar. el.—With what does this correspond in man and the lower vertebrates? If it represents the *oliva* or "olivary body," its position is reversed from that in man in relation to the apparent origin of the *N. hypoglossus*.

Area ovalis.—Ar. ov.—With what does it correspond in man and the lower vertebrates? What are its relations to the several columns of the myelon and metencephalon?

Aula.—a.—What are its precise limits? In the cat, and other forms with a large *medicommissura*, this commissure may be regarded as its caudal boundary; but in man, where the commissure is smaller, and in the lower vertebrates where it is wholly absent, the question of limitation is more difficult.

Auliplexus.—apx.—The plexus which appears near the dorsal end of the *aula* on each side. This plexus is continuous, through the *portiplexus*, with the *proplexus*, and apparently also with the diaplexus, but the relations of the latter are doubtful.

As to the plexuses in general, are they formed as stated by Quain (A, II, 545), and other authors, by the intrusion of the free border of the velum, or of processes thereof, still covered by the endyma, into the various cavities, or as recently stated by Mivart (B, 266)?

"The choroid plexuses of the lateral ventricles are (like those of the third) merely portions of the ependyma, which happen to be very vascular, and are not really intrusions from without."

This statement is so positive that, though unsupported by figures, or detailed description, I forbear to affirm the contrary. So far as I can judge, however, the *proplexuses* are intrusions of the pia, while the *diaplexuses* seem to correspond more nearly with the view of Mivart. In the one case, the fold of velum bears to the fold of endyma the same relation which an abdominal viscus bears to the visceral layer of peritoneum; in the other case, the plexus may be compared to a fold of omentum.

Carina (fornicis).—*ca. f.*—How nearly constant is it, and what is its significance?

Cauda (*striati*).—*cd. s.*—Is it distinct in the cat? Has it the relations described in man by Cuvier (B, III, 51), and others, and more recently and fully by Dalton (*1*, 13)?

Spitzka says (*7*):—

"I have identified this structure in the cat; it does not make as fine a sweep as in man, but is distinct at the roof of the inferior horn and loses

itself, as has long been known in the case of the human brain, near the *Nucleus amygdalæ*. Prof. Wilder's term is the only admissable one, both as being descriptive and on grounds of priority."

Chiasma.—ch.—How complete is the decussation? Of course, microscopic sections must be made, but something might be ascertained by tearing apart the fasciculi after proper treatment to harden the nervous tissue, and soften the connective.

Cimbia.—cmb.—Without seeing Gudden's paper, I have assumed that this is the "*tractus transversus pedunculi*" mentioned by Meynert (A, 737). Something of its course after it enters the crus may be seen from microscopic sections; I have not examined its dorsal end.

Commissura fornicis.—Cs. f.—Is it constant in the cat, and is it represented in man and other mammals. Is it a true commissure?

Crista (*fornicis*).—*crs. f.*—What are its histological composition, its function, and its morphical significance? In what other animals does it exist? See my paper (*7*).

Diatela.—dtl.—The roof of the "third ventricle." What is its histological composition? What is its relation to the *velum*, or the *pia* in general? How are the diaplexuses connected with it?

Diaplexus.—dpx.—Are these formed by the intrusion of the border of the velum, or by only a fold of endyma? See *auliplexus*.

Foramen Magendie.—Fm. Mg.—The alleged communication between the metacœlia "fourth ventricle" and the "subarachnoid space." Does it exist in the cat? What are its exact position and form? Is there more than one? Does it permit the passage of liquid in one or both directions?

Flocculus.— flc.—Is this represented in the cat?

Hypocampa.—hmp.—What is its relation to the fornix and the fimbria?

Insula.—ins.—Is the "Island of Reil" represented in the cat by any distinct elevation? If not, what part of the surface corresponds with it?

Interoptici.—iop.—Is this pair of lobes, discovered by Spitzka (*4*, *5*, and *11*,) in some reptiles, represented in the cat?

Lyra.—ly.—What are its form, extent, connections and manner of formation? Is it in fact a distinct structure, or only a surface?

Metatela.—mttl.—The membraneous roof of the "fourth ventricle." What are its form, attachments and histological composition? What are its relations to the *metaplexus?*

Myelon and *metencephalon* (medulla). Leaving their histology out of the question, I have not been able to satisfy myself regarding the relations and nomenclature of the visible components of these parts.

Pia (*mater*).—*pi.*—Does it consist of one, two, or more layers? What are the relations of its layers to the *Fissura media*, and to the intervals between the cerebellum and hemispheres, and the cerebellum and medulla?

Porta.—p.—In my paper (*3*) are given reasons for considering that there are two portæ leading from the mesal aula in the two procœliæ.

Prægeniculatum.—prgn.—Is there not some external or structural line of demarcation between the *thalamus* and the *prægeniculatum?*

Pulvinar.—plv.—Has this any distinct representative in the cat?

Quadrans.—q.—How constant are the inequalities of the surface which enable us, in some cases, to define this area?

Radix intermedia (*rhinencephali*).—*Rx. in.*—Is this ever, in the cat, a distinct root?

Septum lucidum.—Spt. lu.—Is there ever, except in man, any space or *pseudocœlia*, "fifth ventricle," between its two lateral halves? Are these halves ever separated by a prolongation of the pia, or only by connective tissue, or are they ever actually fused so that the true nervous tissue is continuous?

Sulcus habenæ.—Sl. h.—Is the line of reflection of the endyma from the *thalamus* always along the same line, or at the same distance from the habena?

Tænia.—tn.—Is the "*tænia semiculcularis*" a distinct band in the cat? If so, what are its relation with the rima, the proplexus and fimbria?

Terma.—t.—(lamina terminalis). What is its histological composition? Shall the name be held to apply also to the very thin portion of the cephalic wall of the *aula* between the *præcommissura* and the *crista?*

Valvula.—vv.—The roof of the longer and cephalic part of the epicœlia. Does it consist of true nervous tissue, wholly, or even in part, excepting at the place of attachment of the *NN. trochleares?* Is its ectal surface covered by pia? What histological changes occur at its connections with the *cerebellum* and *postoptici?*

Velum (interpositum).—vi.—What is the relation of this to the folds of pia, and to the thalami and fornix?

D.—EXPLANATION OF THE PLATES.

All of the preparations from which the figures are drawn are in the Museum of Cornell University, and are accessible for examination to those who may desire to verify the figures or the descriptions.

In most cases, each figure is based upon more than one preparation. Encephalotomists need not be reminded of the difficulty of obtaining a preparation which shows many points of structure equally well. Since the present paper is only general, and does not aim to indicate individual peculiarities, or those of sex, breed, or age, most of the figures may be regarded as representing what may be called an *average cat's brain.* It is obvious that a very large number of specimens would need to be carefully compared in order to confer upon any generalization respecting sex, etc., a trustworthy character.

It will be noticed that, excepting when there was some special reason for a contrary course, the figures have been uniformly placed in one of two positions. The symmetrical figures are so placed that the meson corresponds with that of the observer, the two sides being right and left like the observer's eyes. The unsymmetrical figures, representing the lateral or mesal surfaces, natural or in section, are usually so placed that the cephalic end points to the left of the observer.

In a short paper (17) the writer has previously urged the desirability of a uniform position for anatomical figures, and suggested that the head end should be always toward the left. As is stated above, while this seems to be most advantageous for unsymmetrical figures, the symmetrical ones are more easily understood and compared in the position which is usually given them.

The obliquity of fig. 17 was necessary in order to show the *Fissura hypocampæ* in its whole length. That such a position is undesirable, as a rule, may be inferred from the unwonted emphasis with which it was condemned by the late Prof. Jeffries Wyman :—

"The photograph is from an oblique point of view, which I believe people will never learn to be a bad one. If the view had been full front, or full side, or full anything, it would have been better than this."—The American Naturalist, II, 52.

Most of the figures are twice the diameter of the preparations, and, with the exception of figures 1 and 2, it should have been better to make the enlargement four or five diameters. Aside, however, from the greater expense which this would have involved, such a degree of enlargement would have rendered it not only possible but necessary to show certain details of structure upon which my information is, at present, imperfect.

All of the figures have been drawn from my own preparations by Miss G. D. Clements, B. S., at the time a student in the Natural History Course in Cornell University.

Artists and anatomists who have undertaken to represent the details of encephalic structure understand the difficulties of the task, and will admit that the omissions and inaccuracies to which attention is called in the descriptions are both few and unimportant compared with the general thoroughness of the work. Indeed, for all the deficiencies, I hold myself much more responsible than the artist, by whom some of the figures were drawn at least four times, twice upon stone.

PLATE I.

Fig. 1.—The dorsal aspect of the brain. Enlarged two diameters.

The general form and some of the fissures are drawn from prep's 288 and 289, the bisected brain of a white and Maltese ♀ ; but the fissures of the right hemisphere are derived from several different preparations.

The *Lobi olfactorii* (*L. ol.*) are made somewhat too prominent, but there is considerable difference between cats in this respect, although much less than between dogs.

The general features of the *cerebellum* (*cbl.*) are well shown. The *Lobi laterales* (*L. l.*) have only a fair proportion to the median lobe or *vermis* (*vm.*), instead of the preponderance which they have in the human brain. The lateral contortion which characterizes the caudal aspect of the vermis in adult cats (as shown in my paper, 10, 221, pl. i, fig. 1 and 2) does not affect the dorsal part.

Of the *metencephalon* (*mten.*), and *myelon* (*my.*), the following features

are shown: The *Fissura dorsimesalis* (*F. dms.*), or "Posterior fissure;" the dorsilateral fissure (*F. dl.*); the *Columna dorsalis* (*Clm. d.*), and the *Clm. lateralis* (*Clm. l.*); on the right side, the principal trunk of the *N. accessorius* (*N. ac.*), and the dorsal or sensory funiculi of the first spinal nerve (*N. cv. 1.*).

As already stated, the fissures of the hemispheres are differently represented upon the two sides. The combination of the two kinds of fissural arrangement in a single figure serves to illustrate the extent of the lateral variation and compensation to which attention was called by me in 1873 (10, 232).

The postsylvian and supersylvian (*FF. ps.* and *s.*) are represented as united upon the left side, but separated on the other. The junction is more common, but the separation is sometimes complete. The case is somewhat similar with the *lateralis* and *medilateralis* (*FF. l.* and *ml.*). The *ansate* fissure (*F. an.*) presents itself in so many forms that it is difficult to determine its normal condition and connections. It is usually joined with either the *lateralis* or the *coronalis* or both; when separate, it often is triradiate; but occasionally, as in prep. 294, on the left side, it forms a nearly straight fissure at right angles with the lateralis and coronalis, and wholly independent of them both. This condition is represented on the right side of fig. 1. This fissure demands fuller investigation, especially with reference to its representation in the human brain.

So far as I know, the following junctions of fissures which, on some grounds, may be regarded as fissural integers, are constant in the cat: Of the *rhinal* (*rh.*) with *postrhinal* (*prh.*), and of the *sylvian* (*s.*), with the point of their union; of the *superorbital* (*so.*), with the rhinal; of the *callosal* (*cl.*), with the *hypocampal* (*hmp.*), and with the *preradical* (*prrd.*), when it exists.

The following junctions are common: Of the *diagonal* (*dg.*), with the *anterior* (*a.*); of the *postsylvian* (*ps.*), with the *supersylvian* (*ss.*); of the *medilateral* (*ml.*), with the *lunate* (*ln.*), and with the *lateral* (*l.*), or the *confinis* (*cf.*); of the *marginal* (*mr.*), with the *postmarginal* (*pmr.*); and of the *ansate* (*an.*), with the *lateral* or *coronal* (*cor.*), or both.

The junction of the *cruciate* (*F. cr.*), with the *splenial* (*F. sp.*), which Guillot has seen once, Krueg twice (*Krueg, 2*, 620), and Pansch (*1*), three times out of fourteen, has been observed by me on only four of the many hemispheres examined. I have never seen a union of the *splenial* with the *postrhinal* (*prh.*).

I have never observed the union of the anterior and posterior fissures to form the "first or lowest arched fissure" of the Canidæ. On the other hand, as stated by Krueg (*2*,613), and by myself (11,229), this union sometimes fails with domestic dogs; hence, in this as in many other respects, the cat presents less tendency to vary.

A junction of two fissures is usually marked by a less depth of the compound fissure at that point, constituting a concealed "transition convolution" or "pli de passage," which may be seen by separating the sides or by slicing off the cortex.

Fig. 2.—The sinistral aspect of the brain. From prep. 288. Enlarged two diameters.

The *Lobus olfactorius* (*L. ol.*) is made somewhat too prominent. The curved line upon its lateral surface indicates, approximately, the boundary of the more cephalic portion of the pero or ectal layer, whence arise the *Nervi olfactorii*. These nerves are not shown.

The features of the *Crus olfactorium* indicated by *lm. cin.* and *lm. alb.* are more fully shown upon fig. 3.

The *Nervus opticus* (*N. op.*) projects from the ventral margin of the figure, and the *Fissura Sylviana* (*F.s.*) is seen dorso-caudad of it.

The ventral end of this fissure, as is always the case in the cat, joins the fissure which forms the dorsilateral boundary of the *Tractus olfactorius* (*Tr. ol.*), and the cephalic and caudal divisions of that fissure are called respectively *rhinalis* and *postrhinalis* (*FF. rh.* and *prh.*). So much of the hemisphere as lies caudad of the *F. Sylviana* forms the *Lobus temporalis* (*L. tmp.*), the ventral extremity of which is the *Lobulus hypocampæ* (*Ll. hmp.*).

The cerebellum (*cbl.*) presents the narrow median lobe or *vermis* (*vm.*), and the *Lobus lateralis* (*L. l.*). Near the ventricephalic angle of the latter, two or three of the laminæ of the second tier project as the *Lobulus appendicularis* (*Ll. ap.*), which is seen better in fig. 3.

The *metaplexus* shown in fig. 3 (*mtpx.*), has been removed, so as to expose the prominent *Eminentia auditoria* (*Em. au.*), whence springs the *N. auditorius* (*N. au.*).

Just ventrad of the eminence is the *trapezium* (*tz.*), and cephalad of this is the *pons* (*pn*).

Between the pons and the hemisphere appears a part of the *Crus cerebri* (*Cr. cb.*), and cephalad of this is the slender *N. trochlearis* (*N. tr.*), which, by inadvertence, seems to emerge from the *F. postrhinalis* instead of from between the cerebellum and the hemisphere.

The *N. trigeminus* (*N. trg.*) has been cut short, in order the more clearly to show that it emerges just caudad of the pons, and not through it as in man.

The remaining nerve origins are indicated only by dots. Those of the *NN. glossopharyngeus, vagus* and *accessorius* (*NN. gph., v.* and *ac.*) form a series. At the side of the myelon, near the dorsal and ventral borders, are seen the origins of the first cervical nerve (*N. cv. 1.*).

In this figure the fissures are accurately represented as they are in the preparation, excepting that the small *F. lunata* (*F. ln.*), has been added from prep's 519 and 520. The small *F. intermedia* might well have been inserted between the dorsal ends of the *FF. anterior* and *postica* (*FF. a* and *p*).

PLATE II.

Fig. 3.—The *basis encephali*, or ventral aspect of the brain. Enlarged two diameters.

The proportions and general features are from the brain of an adult ♀,

Maltese and white, prep's 288, 289. Some details of the *Area præchiasmatica* (the region cephalad of the chiasma) are from 461 and 527; of the *Ar. postpontilis* (the region caudad of the pons) from 358, 454 and 491, and of the intermediate *A. cruralis* from 422, 506, and 527.

Most of the nerves and cerebral fissures are lettered on the right side, and most of the other parts on the left. Some of the left nerves are cut short, and the left *N. trochlearis* is not shown at all.

The *Lobi olfactorii* (*Ll. ol.*), and are made too long, and the *hypophysis* (*hph.*) is too short.

Attention is called to the following points, chiefly in comparison with the human brain :—

The absence of a distinct *Radix intermedia* (*Rx. in.*) of the *Crus olfactorium*, corresponding with the so-called "middle root of the olfactory nerve" in man. The part so designated upon the plate is apparently only an area, comparatively undifferentiated, between the more or less fibrous tracts forming the *Radices mesalis* and *lateralis*.

The turning of the *Rx. mesalis* (*Rx. ms.*) over the margin of the brain so as to appear upon the meson.

The distinction of the *Rx. lateralis* (*Rx. l.*) into a lateral gray and a mesal white tract, the *Limes cinerea* (*Lm. cin.*) and the *Lm. alba*.

The great extent of the (*Locus*) *præperforatus* (*prpf.*), and its division into a cephalic more prominent portion (*Pt. p.*), and a caudal depressed portion (*Pt. d.*). Both portions are "perforated," but the degree of furrowing of the *Pt. prominens* varies considerably. These furrows exist in some other Carnivora.

The width of the *hypophysis* (*hph.*), and the crenation of its caudal border, indicating the existence of an ental subspherical mass, which is covered by an ectal layer, the thinness of which, in the caudal region, permits the contour of the former to be seen.

The slight degree of separation of the *albicantia* (*abn.*), which are here nearly concealed by the hypophysis, but more fully shown in fig. 12.

The distinctness of the *cimbia* (*cmb.*), or "*tractus transversus pedunculi*," which is better seen in fig. 11.

The slight extent of the true *postperforatus* (*ppf.*); the only part which is really "perforated" is a small triangular area just caudad of the albicantia, and partly hidden by them.

The less caudo-cephalic extension of the *pons* (*pn.*); this exposes more of the *Area intercruralis* (*Ar. ic.*) than in man, and uncovers the *trapezium* (*tz.*), which, in man, is wholly concealed. Connected also with this feature of the pons is the fact that the *N. abducens* (*N. abd.*) passes directly cephalad from its origin a little caudad of the pons, whereas in man it is forced to curve around the caudal border. Finally, the *N. trigeminus* (*N. trg.*), in place of emerging through the pons as in man, arises wholly caudad of it, although closely applied to its surface.

The greater extent of the *Ar. cruralis*, which may be ascribed both to

the less extent of the pons, and the less degree of flexure of the whole brain at the mesencephalic region.

The greater width of the *Tractus postrhinalis* (*Tr. prh.*), which includes the surface of the *Lobulus hypocampæ* (*Ll. hmp.*). In man, indeed, this part is hardly visible on account of the prominence of the convolutions laterad of the *F. postrhinalis*.

The apparent origin of the *N. oculomotorius* (*N. ocm.*) laterad of the meson, and just caudad of the cimbia (*cmb.*).

The appearance of a division of the ectal layers of the pontile fibres into three groups, cephalic, caudal and intermediate, the latter partly overlapped by the other two.

The appearance of a faint band crossing the trapezium a little obliquely between the origins of the *NN. abducens* (*N. abd.*) and *facialis* (*N. f.*). The distinctness of this band varies.

The origin of the *N. hypoglossus* (*N. hg.*) laterad of the *Area elliptica* (*Ar. el.*), which might otherwise be taken as the surface of the *oliva* or "olivary body" of man. The determination of this point involves some comparisons and sections which I have not yet made, so I merely indicate the part by a descriptive name and leave the question open.

The close association of the roots of the *NN. glossopharyngeus* (*N. gph.*), *vagus* (*N. v.*), and *accessorius* (*N. ac.*). The long caudal nerve is of course accessorial, and the cephalic funiculi are unquestionably glossopharyngeal; but how the intermediate funiculi should be assigned, I am not yet sure.*

The marked prominence of the ventro-lateral region of the metencephalic continuation of the *Columna lateralis myelonis* (*Clm. l.*), forming an elevation to which I have applied the provisional name *Area ovalis* (*Ar. ov.*).

The absence of any superficial decussation of the *pyramids* (*py.*). Hence, the *F. ventrimesalis* (*F. vms.*) or "anterior fissure," is uninterrupted. The *F. ventrilateralis* (*F. vl.*) is deflected at the caudal end of the *Area elliptica*.

Fig. 4.—The mesal surface of the right half of the brain (hemiencephalon dextrum). Enlarged two diameters.

The general features are from the same brain as fig. 3, but some features are derived from prep's 290, 304 and 454.

The surfaces shown in this figure are of four kinds, as follows :—

1. The natural surfaces which are covered by *pia*. These are the mesal aspects of the *hemisphere* (*hem.*), and the *Lobus olfactorius* (*L. ol.*).

2. The natural mesal surface (*Ar. spt.*) of the right half of the *septum lucidum*, which, in the cat, is in contact with its lateral homologue, or separated therefrom only by a thin layer of connective. I have never observed an interval corresponding to the *pseudocælia* or "fifth ventricle" of man.

*In a paper on the N. vagus in the cat, presented at the same time with this, Prof. T. B. Stowell has given a fuller account of the relations of these nerves.

3. The natural endymal surfaces of the true *cœliæ* or "ventricles." Of course the "lateral ventricles," procœliæ, do not appear.

4. The cut surfaces of the *commissures* and other parts which cross the meson, or lie upon it. In the *cerebellum* (*cbl.*) the relative areas of the ental *alba* and the ectal *cinerea* forming the *arbor vitæ* (*arb.*), are indicated by the shading; with less definiteness, the alba is shown in the *callosum* (*cl.*), the *fornix* (*f.*), the *præcommissura* (*prcs.*), the postcommissura (*pcs.*), the *commissura habenarum* (*cs. h.*), and the *chiasma* (*ch.*). The section of the *medicommissura* (*mcs.*) should appear as if composed, at least chiefly, of cinerea, but no attempt has been made to indicate the nature of the cut surfaces of the *Crista fornicis* (*Crs. f.*), the *terma* (*t.*), the *hypophysis* (*hph.*), the *infundibulum* (*inf.*), the *basicommissura* (*bcs.*), the *conarium* (*cn.*), the *optici* and *postoptici* (*op.* and *pop.*), the *valvula* (*vv.*), the *Crura cerebri* (*Cr. cb*), the *metatela* (*mttl.*), or the rest of the epencephalon and metencephalon (*mten.*). The extent of the transverse fibres of the *pons* (*pn.*) should have been represented, at least approximately.

So much of the cephalic boundary of the *aula* (A.) as intervenes between the *præcommissura* (*prcs.*) and the *crista* (*Crs. f.*) is very thin, and is too indistinctly shown in the figure. Neither here nor at any other point is there any such interruption of the wall as would form a communication between the true cœliæ and the pseudocœlia or the ectal surface of the brain. It is probable that the presence of such a communication as is ascribed to the human embryo, and to some animals in Quain (A, II, 543), is due to the artificial rupture of the natural connections.

Attention is called to the following points, chiefly in comparison with the human brain :—

The appearance of the *Rx. mesalis* (*Rx. ms.*) on the meson, and the presence of two shallow fissures, *postradicalis* and *præradicalis* (*FF. prd.* and *prrd.*) between it and the adjoining surfaces of the hemisphere.

The large size of the commissures, especially the *medicommissura* which nearly fills the diacœlia (*dc.*).

The non-appearance of the *porta* when the meson is viewed squarely; it is doubtful whether the human "foramen of Monro" is really visible from the meson.

The less extent of the *callosum*, especially of its rostrum (*rm.*). In some human brains the rostrum does not extend so far as is usually represented.

The darker spot on the section of the hypophysis represents the space occupied by the ental mass, which has been removed.

The relations of the pia are not indicated at all, and are not well understood, especially between the cerebellum and the metencephalon and mesencephalon.

PLATE III.

With the exception of fig. 13, all the figures upon this plate represent the natural surfaces of regions which are more or less completely concealed by other parts in the undissected brain.

Fig. 5.—The cephalic aspect of the Prosencephalon after the removal of the *Lobi olfactorii*. From prep. 294. Enlarged two diameters.

The hardened brain was transected at the *FF. postica*, so that the preparation includes only the cephalic two-thirds of the prosencephalon.

The drawing represents the preparation tilted up so as to expose the ventral aspect foreshortened.

As compared with fig. 6, this might well have been made of the natural size. A less regularly symmetrical brain would have been more instructive. One of the *Crura olfactoria* should have been divided at a little greater distance from the prosen.

So far as appears in the figure, the fissures are remarkably alike upon the two sides; the left *F. ansata* (*F. an.*) however, only the meso-cephalic end of which appears in the figure, presents the somewhat unusual but very suggestive condition of entire independence of the *F. lateralis* (which is invisible) and the *F. coronalis* (*F. cor.*). On the right side it is joined by the former fissure.

The right *F. sylviana* (*F. s.*) is shorter than the left, and presents a slight terminal bifurcation which is not shown.

In consequence of the removal of the *Lobi olfactorii*, and the tilting of the whole preparation, so much of the *F. rhinalis* (*F. rh.*) as lies cephalad of its union with the *F. superorbitalis* (*F. so.*) is practically obliterated, and the remainder of it is so foreshortened as to appear as an insignificant intermediate portion of an extensive u-shaped fissure formed by the *FF. sylviana* (*F. s.*) and *superorbitalis* (*F. so.*). The appearances thus presented are suggestive in view of the idea of Meynert (*1*, 12), which I also entertained at one time (10, 225), that the *F. superorbitalis* represents the "anterior branch" of the human *F. sylviana*, and that the intervening part of the brain corresponds to the "operculum."

A slight preponderance of the left hemisphere just caudad of the F. sylviana is somewhat exaggerated in the figure, and the *Crura olfactoria* (*Cr. ol.*) should differ less in form and in their distance from the meson.

The *FF. olfactoriæ* (*F. ol.*) appear as little more than shallow furrows.

On account of the foreshortening of the ventral aspect, the line of separation of the *Portio prominens* (*Pt. p.*) and the *Pt. depressa* (*pt. d.*) is indistinct. The *Ll. hypocampæ* (*Ll. hmp.*) on each side has been flattened by pressure, and is so represented.

Fig. 6.—The caudal aspect of the Prosencephalon, with part of the Diencephalon, after the removal of the other parts of the brain.

From prep. 292, an adult ♀.

The dien. has been transected so as to leave a concave surface which, at the meson, is close to the caudal border of the medicommissura (*mcs.*), but rises at the sides so as to coincide nearly with the caudal surface of the prosencephalon.

The postcommissura has been removed, and the slender transverse band (*Cs. h.*). Just ventrad of the *splenium* (*sp.*) is the *Commissura habenarum*.

Had the postcommissura been left, the intervening space would be a foramen, *Fm. conarii.*

The shallow depression of the ventricaudal surface of each hemisphere just laterad of the splenium, represents the area of contact of the *opticus.*

The cerebral fissures are markedly unsymmetrical, and thus in contrast with those of fig. 5. The right *F. postrhinalis* (*F. prh.*) is the longer, and the right *postsylviana* (*F. ps.*) joins the *F. supersylviana*, although the place of union does not appear in the figure. On the contrary, by reason of the perspective, it seems to be joined by the *F. medilateralis* (*F. ml*).

The *LLl. hypocampivrum* have their proper rounded form in this preparation.

Part of the *diacœlia* (*dc.*) appears dorsad of the medicommissura, and part on its ventral side. In man, the commissure is smaller, and the cœlia correspondingly more extensive. On account of the removal of the hypophysis and infundibulum, the diacœlia opens freely at the *Fm. infundibuli* (*Fm. inf.*).

Fig. 7.—The dorsal aspect of the Diencephalon (thalami and geniculata), and of the Mesencephalon (optici and postoptici).

From preps. 397 and 494, adult ♀♀, 423, a nearly adult ♀, and 506. Enlarged two diameters.

The principal features of this figure were drawn from prep. 506. The preparation was made by lifting the caudal ends of the hemispheres, and gradually separating them, with the callosum, fornix and velum, from the subjacent parts. The epen. and meten. were then removed by a transection just caudad of the postoptici.

The *valvula* (*vv.*) was torn from prep. 506, so it is drawn as it appeared in prep. 494, after inflation by blowing air from the diacœlia through the mesocœlia or *iter.*

The *Commissura habenarum* (*Cs. h.*) is really more distinct in prep. 397 than appears in the figure. The habenæ (*h.*), their sulci (*Sl. h.*) and the lines of reflection of the endyma are taken from prep. 422, and their distinctness is not exaggerated in the figure. Their morphical significance is to be noted in connection with the general question of cœlian circumscription. Upon this point, see a brief note in "Science" (*12*).

The complete roof of the diacœlia, the *diatela* (*dtl.*), is shown in fig. 10.

As compared with the homologous parts in man, the feline *postoptici* (*pop.*) and *geniculata* (*pgn* and *prgn.*) are larger, while the *thalami* (*th.*) seem to be only the mesal continuations of the *prægeniculata* (*prgn.*), and to lack altogether the pulvinar or "posterior tubercle" of man.

Fig. 8.—The caudal aspect of the Mesencephalon, with parts of the adjoining regions. From prep. 506.

The plane of transection coincides nearly with the caudal surface of the *postoptici* (*pop.*), and has divided the *pons* (*pn.*), a little caudad of its middle. The *valvula* (*vv.*) was torn from this preparation, and the line of its attachment is not distinctly shown. Something of its position may be judged from fig. 7. The caudal orifice of the iter or *mesocœlia* (*msc.*) is

shown here as a nearly regular circular spot; in reality, it presents a slight mesal extension at both the dorsal and ventral sides. Indeed, when carefully examined, the so-called "aquæductus sylvii" is far from being a perfectly simple and uniform tube; its form in man is indicated in Reichert's fig. 31 (A, taf. 4). Among the lower mammals it is usually larger, and with the lower vertebrates it often has the proportions of a true cœlia, with lateral extensions.

The *cimbia* (*cmb.*) is partly seen on the right. The *geniculata* (*pgn.* and *prgn.*) do not project as far as they should. The optici are wholly hidden from view by the prominent *postoptici* (pop.).

Fig. 9.—The sinistral aspect of the Mesencephalon and Diencephalon. From preps. 491 and 506. Enlarged two diameters.

The only cut surface shown in this figure is that caused by the oblique transection between the dien. and the prosen.; the plane of section followed the cephalic border of the *Tractus opticus* (*Tr. op.*), and corresponds with the *Sulcus limitans* between the *thalamus* and the *striatum*.

Crossing the *crus* (*Cr. cb.*) just caudad of the *postgeniculatum* (*pgn.*) is seen the *cimbia* (*cmb.*).

The *Nervus trochlearis* (*N. tr.*) had been removed from prep. 506, and was added from prep. 491.

Upon this figure should appear the *Lemniscus superior* and *L. inferior*, and the *postbrachium* and *præbrachium*, provided they exist in the cat as distinct parts visible at the surface. I have not been able to satisfy myself respecting their exact position and limits in the human brain, and refrain from expressing any opinion concerning them.

Fig. 10.—The dorsal aspect of the Diencephalon, including the diatela. From prep. 301, a half grown ♂.

The object of this figure is to show the existence of a *distinct roof of the diacœlia* independent of the velum, which has been removed. This *diatela* (*dtl.*) presents the appearance of something more than the lining endyma, but its structure has not, so far as I know, been examined. The darker triangular area at the cephalic end of the diatela corresponds with the *delta fornicis* (*dlt. f.*).

Fig. 11.—The Area cruralis, with part of the pons and of the Ar. prechiasmatica. Enlarged two diameters. From preps. 506, 425 (nearly adult ♀) and 461 (♂).

So small and so numerous are the parts shown in this figure, that it should have been yet more enlarged.

The *Lobi temporales* have been divided at different levels on the two sides. From the right, only the extremity, or *Ll. hypocampæ*, has been removed, and the section of the *medicornu* (*mcu*) which is here cut very obliquely, is a slightly curved space completely circumscribed by a nervous wall. Neither in the cat, nor—contrary to the common belief and the explicit statement in Quain, A, II, 542, 544—in man, does the *rima* or "great transverse fissure" extend to the *tip* of the medicornu.

Where the *Ll. hypocampæ* rests against the *Tractus opticus* (*Tr. op.*).

there is usually a deep notch which may be called the *Incisura hypocampæ* (*Inc. hmp.*).

On the left side, the hemisphere was dissected off so as to leave two cut surfaces. One of these surfaces is plane and nearly horizontal, and lies at about the level of the dorsal end of the *postgeniculatum* (*pgn.*). The other is convex, and extends from the cephalic border of the former obliquely to the ventral surface of the brain; it corresponds closely with the cephalic border of the *Tractus opticus* (*Tr. op.*).

The left *medicornu* is cut at about the middle, and at nearly a right angle with its course; hence its lumen presents its characteristic crescentic section, the ental boundary being the convex surface of the *hypocampa* (*hmp.*).

The cephalic margin of the medicornu is here seen to reach the surface of the hemisphere close to the *Tractus opticus*, and this narrow line of interruption of the true nervous wall of the cornu constitutes the *rima*. The scale upon which this figure was drawn did not permit the relations of the *pia*, the *velum*, and the *proplexus* to be shown, and the undulations of the ectal surface, corresponding with the *FF. hypocampæ* and *fimbriæ*, and the *fasciola* and *fimbria* are hidden by the projecting postgeniculatum.

Most of the cephalic portion of the brain has been removed, but the *Portio depressa* (*Pt. d.*) of the *præperforatus* is seen, with part of the *Pt. prominens* (*Pt. p.*). The removal of most of the *chiasma* (*ch.*) exposes the form and extent of the *Recessus opticus* (*R. op.*).

The *pons* has been transected obliquely, and its caudal portion removed together with the rest of the epen. and the metencephalon.

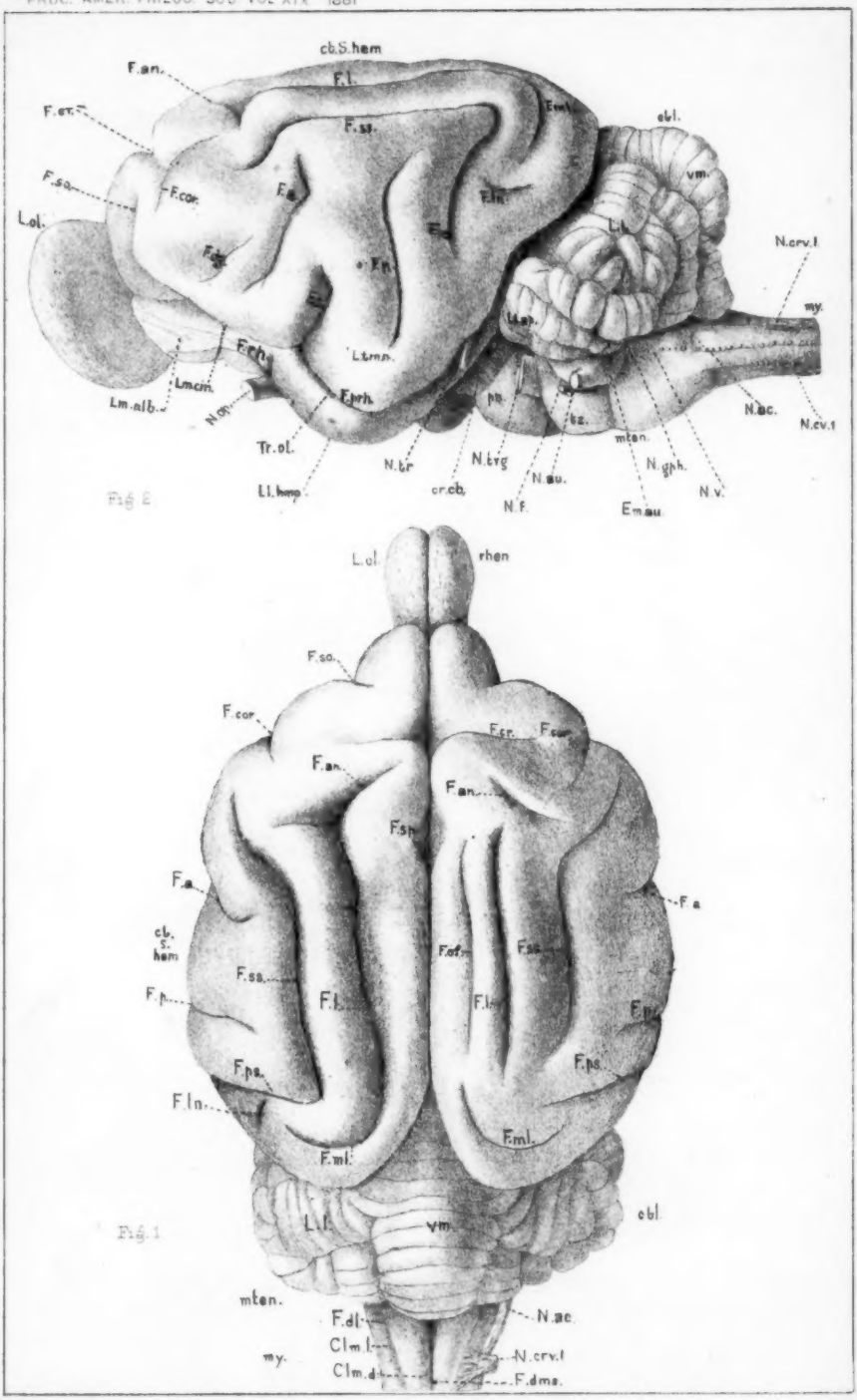
The left *Crus* (*Cr. cb.*) is seen in its whole length, excepting a small part concealed by the slightly projecting cephalic border of the pons. The well-marked *cimbia* (*cmb.*) may perhaps be regarded as the boundary between the diencephalic portion of the crus (*Pt. dien.*) and the mesencephalic portion (*Pt. msen.*), which more directly supports the *optici* and *postoptici*; in man, this part seems to be almost wholly concealed by the pons.

The right *N. oculomotorius* (*N. ocm.*) is seen to emerge from the crus just caudad of the mesal end of the cimbia, and just laterad of the *Sulcus intercruralis lateralis* (*Sl. ic. l.*). A marked longitudinal ridge of the crural fibres separates from the *postgeniculatum* (*pgn.*) the depressed area which, from its forming approximately the fourth of a circle, I have called the *quadrans* (*q.*).

The *albicantia* (*abn*) are more closely united than in man, but they are large, white, and perfectly distinguishable. The shallow furrow between them, together with the u-shaped furrow which forms their cephalic boundary, may be named *Sulcus triradiatus* (*Sl. trd.*).

The hypophysis has been removed so as to expose the *Tuber cinereum* (*T. cin.*), and the thin raised margin of the *Fm. infundibuli* (*Fm. inf.*).

Just caudad of the albicantia, and partly overhung by them, is a small triangular depressed space with distinct perforations; this seems to be the true *postperforatus* (*ppf.*).



WILDER ON BRAIN OF CAT

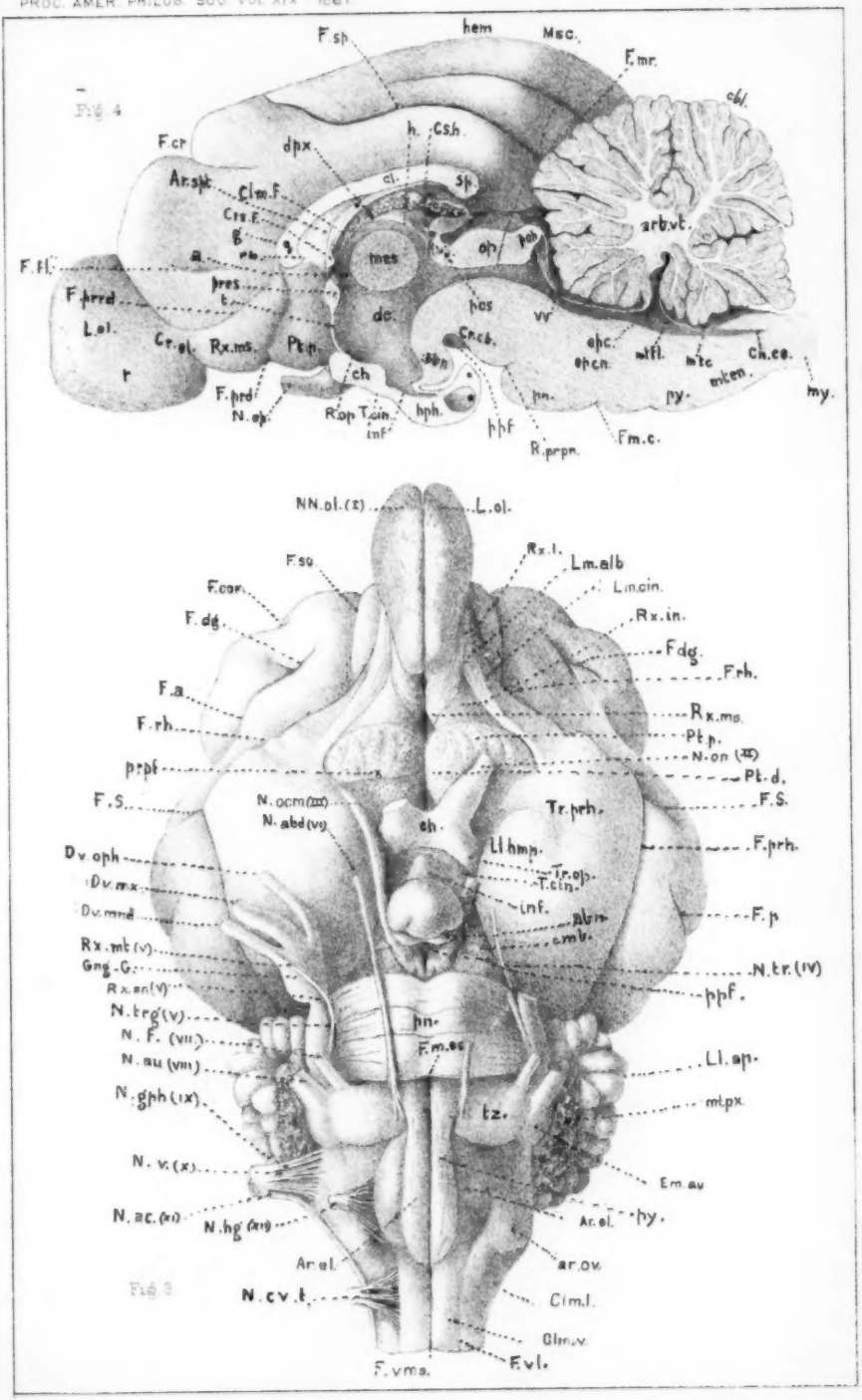


Fig 4
F.sp
hem
Msc.
F.mr.
chl.
F.cr
dpx
h.
Csh.
Ar.sph.
Clm.F.
Crs.F.
cl.
sp
arb.vt.
F.fl.
mes
oph
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pres
F.prd
dc.
hcs
vv
L.ol.
Cr.ol.
Rx.ms.
Pt.p.
Cn.cb.
ch
ephc.
ephcn.
wtl.
mtc
Ch.co.
mtcn.
my.
F.prd
N.ab
R.op
T.cin.
inf
hph.
hn.
py.
ppf
R.prpn.
Fm.c.
NN.ol.(x)
L.ol.
F.so
Rx.l.
Lm.alb
F.car.
Lm.cin.
F.dg.
Rx.in.
F.dg.
F.rh.
F.a.
Rx.ms.
F.rh.
Pt.p.
N.on (II)
prpf
Pt.d.
F.S.
N.ocm(III)
N.abd(VI)
ch.
Tr.prh.
F.S.
Dv.oph
Ll.hmp.
F.prh.
Dv.mx
Tr.op.
T.cin.
Dv.mnd
inf.
abm.
F.p
cmb.
Rx.mb(V)
Gng.G.
N.tr.(IV)
Rx.an(V)
ppf.
N.trg(V)
hn.
N.F.(VII)
F.m.ac
Ll.ap.
N.au(VIII)
N.glph(IX)
tz.
mt.px.
N.v.(X)
Em.au
N.ac.(XI)
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Fig 3
N.cv.t.
Clm.l.
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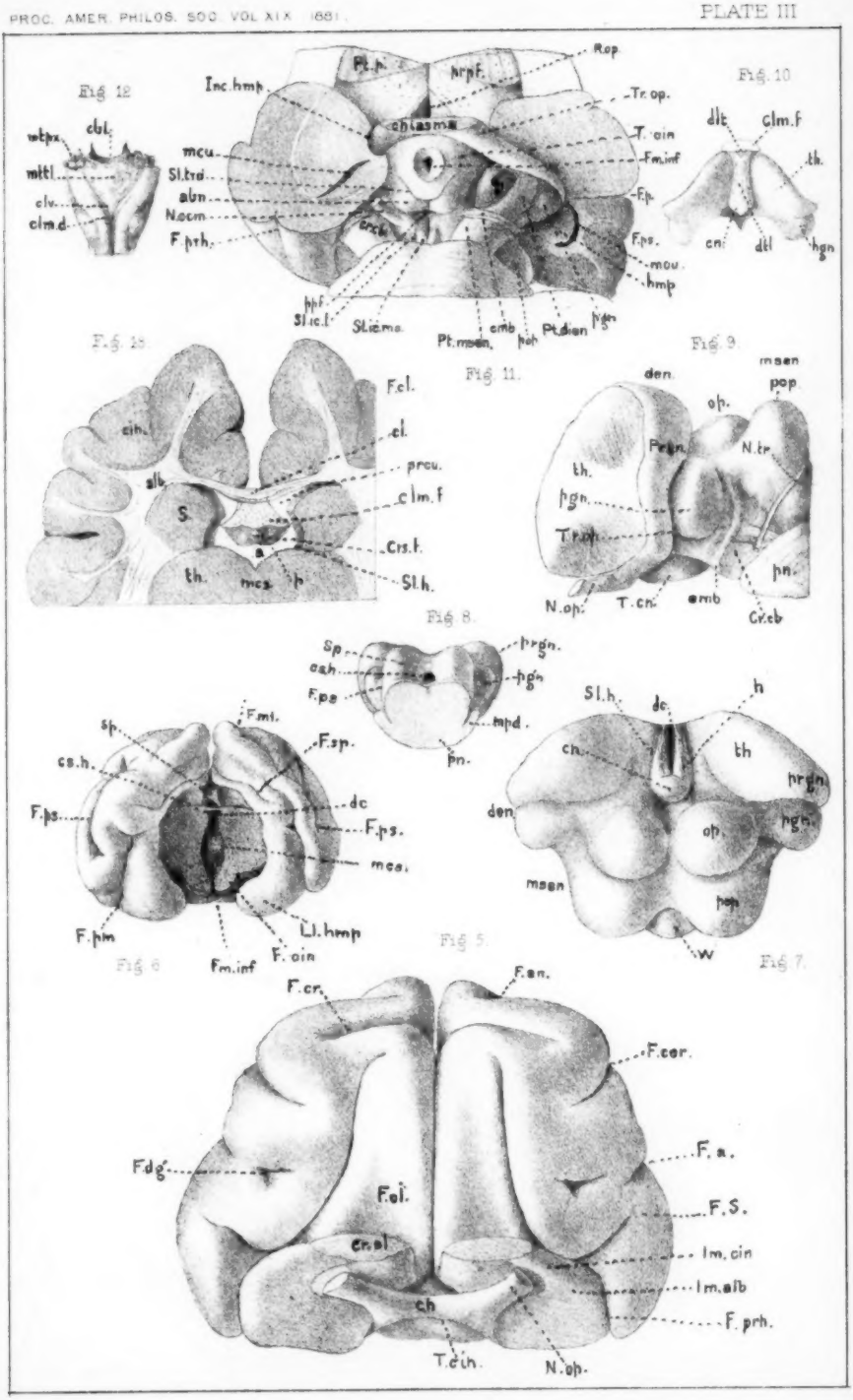
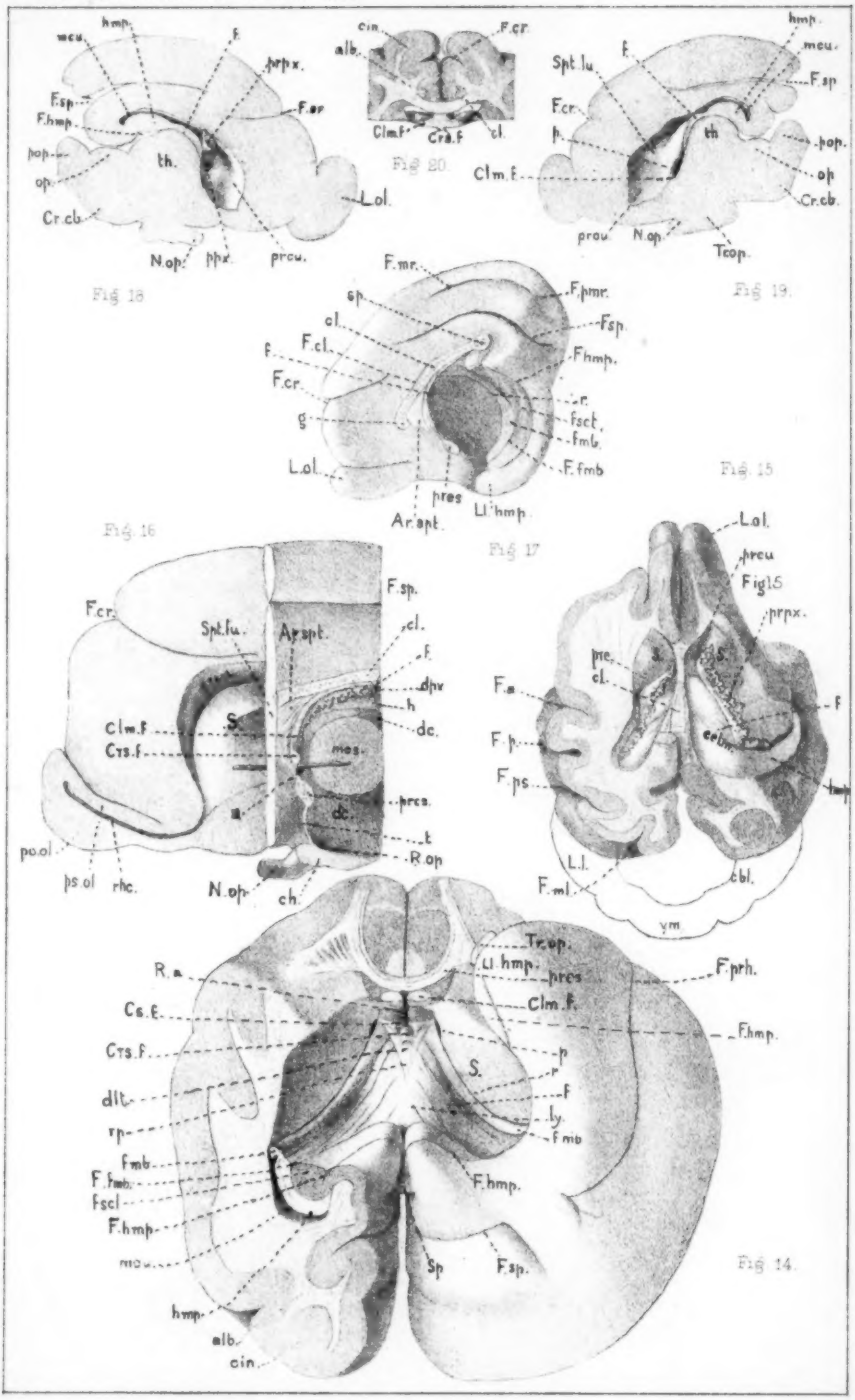
F.vms.
F.vl.



WILDER ON BRAIN OF CAT



WILDER ON BRAIN OF CAT

The entire *Area cruralis* may be more completely exposed by removing the cerebellum and dorsiducting the medulla, as in prep. 425.

Fig. 12.—The dorsal aspect of the Metencephalon or Medulla, showing the metatela or roof of the metacœlia. From prep. 397, adult ♀, 464 and 491.

The metatela here shown is apparently independent of the *pia;* like the diatela it seems to consist of more substantial tissue than simply endyma, but I am not aware that its microscopic structure has been ascertained. I am in doubt respecting the precise limits and attachments of the metatela, and the form and location of the "foramen of Magendie." Hence the figure is vague and unsatisfactory upon these points.

Fig. 13.—Part of an oblique transection of the Prosencephalon and Diencephalon to show the form and position of the *crista*. From prep. 441. Enlarged two diameters.

The brain was transected obliquely at an angle of about 45 degrees with the general longitudinal axis. The plane of section passed from a point nearly dorsad of the genu, through the aula, the medicornua and the albicantia. The figure includes only a part of the caudal aspect of the slice.

The dorsal borders of the hemispheres are divaricated slightly, and the *callosum* (*cl.*) is seen crossing the interval; the slight notch on each side just dorsad of the callosum is the *F. callosalis* (*F. cl.*).

The *striata* (*s. s.*) are seen in section just ventrad of the lateral expansion of the callosum, while the lower part of the figure is occupied by the thalami (*th*), united by the *medicommissura* (*mcs.*). Between each thalamus and the corresponding striatum is a groove, the *Sulcus limitans* (*Sl. li.*).

The *Columnæ fornicis* (*Clm. f.*) are divided nearly at a right angle with their course, and at a point just dorsad of the *crista* (*crs. f.*), which is particularly well shown in this preparation. The open space between the fornix and the thalami is the *aula* (*a.*), and on each side are the *portæ* (*p.*) leading into the *procœliæ*. All the plexuses have been removed.

PLATE IV.

Unlike those of Plate III, all of the figures upon this plate represent cut surfaces, although some natural surfaces are shown also.

Fig. 14.—A ventricaudal view of the *fornix*, with the adjacent parts. From prep's. 507, 463 and 396 (adult ♂). Enlarged two diameters.

The preparations were made while the brain was fresh, so as to permit more flattening of the hemispheres, and consequent exposure of the fornix.

After the removal of the rhinen., meten., epen. and mesen., the thalami and geniculata were excavated piecemeal, so as not to injure or displace the fornix. The cut surface (*s.*) at each side of the fornix (*f.*) is the plane of division of the dien. from the striatum.

The cephalic end of the prosen was then sliced down to the level of the *præcommissura* (*prcs.*), which is seen to send a distinct fasciculus toward the rhinen. on each side. Then the right hemisphere was sliced obliquely

from near the meson dorso-laterad so as to cut the *medicornu* (*mcu.*) and *hypocampa* (*hmp.*) at about the middle of their length. On the left side, the *L. temporalis* was allowed to fall somewhat by its own weight so as to expose the fornix more fully.

The *velum* and all the *plexus* were removed so as to display the peculiar markings of the fornix and its mesal portion which is supposed to represent the *lyra* (*ly.*).

The *portæ* (*p.*) appear both shorter and narrower than they really are, on account of the obliquity of their planes to the line of vision. The v-shaped line called *ripa* (*rp.*) which connects the two portæ, separates the *delta* (dlt.) or entocœlian part of the fornix from the remaining surface, which is wholly outside of the cœlian cavity. The delta forms the roof of the *aula*, the cephalic continuation of the diacœlia between the two portæ, and the ripa is the line of reflection of the *endyma* upon the two *auli-plexus*; the removal of these plexuses causes the rupture of the endyma along the ripa.

At each side, the ripa curves dorsad somewhat sharply so as to reach the dorsal end of the porta; at this point, and dorso-caudad for the entire length of the *rima* (*r.*), the endyma is simply reflected from the contiguous surfaces of the *fimbria* (*fmb.*) and the corresponding border of the *striatum*. Hence the rima is virtually *closed*, and thus wholly distinct from the porta.

On the meson, between the portæ, is seen the *crista* (*crs. f.*), which is unusually rounded in this preparation. The *carina*, which sometimes appears as a slight mesal ridge extending dorso-caudad from the crista, does not appear in this preparation. The *Recessus aulæ* (*R. a.*) is the cleft between the two *Columnæ fornicis* (*Clm. f.*) whose cut ends are seen just caudad of the præcommissura. The shading on the caudal aspect of the columnæ indicates, but rather too distinctly, a slightly depressed area, of which the dorsal part, close to the crista, sometimes presents the appearance of a transverse band, for which I suggest the name *Commissura fornicis* (*Cs. f.*).

After a prolonged examination of many preparations, I am unable to define accurately the limits of the fornix and the *lyra* (*ly.*). A comparison of the accounts given in standard works with the appearances presented by the limited materials at my disposal, leads me to doubt whether the relative extent of the two parts in the human brain is well determined.

The *fasciola* (*fscl.*) is thick, and no part of it presents the denticulations from which its more ventral portion, in man, is called "fascia dentata." The peculiar curve of the hypocampa, medicornu and fasciola is well indicated by the fact that the *F. hypocampæ* (*F. hmp.*), which corresponds nearly with them in direction, is visible in this preparation only at its two ends, near the *splenium* (*sp.*), and near the tip of the *Ll. hypocampæ* (*Ll. hmp.*). Between the fimbria and the fasciola is a depressed line which may be called the *Fissura fimbriæ* (*F. fmb.*).

Fig. 15.—The dorsal aspect of the *procœliæ*, with their *proplexus*. From prep. 465. Natural size.

The especial object of this preparation is to show that, in the cat, *no part of the thalamus appears in the procœlia.* The cerebellum (cbl.) is shown only in outline.

Both hemispheres were sliced from the dorsum to the level of the intermediate part of the *callosum* (*cl.*). This laid open both procœliæ in some degree. The central part of each procœlia is sometimes called *cella media* (*cel. m.*). The right medicornu was then opened to the tip which, however, cannot be seen from the dorsal side.

The floor of the procœlia is seen to be formed by the *striatum* (*s.*), the *fornix* (f.), and the *hypocampa* (hmp.). The proplexus have been turned in opposite directions for the sake of showing the absence of any interval between the fornix and hypocampa—or the fimbria which forms the border of the latter—and the striatum, such as would permit the appearance of the thalamus in the procœlia. Whatever may be the case in man, neither in the cat nor in any other mammal examined by me, is there any separation of the borders of the rima more than will permit the intrusion of the border of the velum to form the proplexus.

It is commonly stated in works upon human anatomy that the thalamus appears in the "lateral ventricle," forming part of its floor. It is possible that the narrowness of the human fornix may permit this to occur; but the part of the thalamus so appearing must be covered by endyma, and should be so described in contradistinction to the larger portion of its dorsal aspect, which is certainly ectocœlian. However this may be in man, it is not the case in any other mammal examined by me, and the explicit statement in both the French and the English editions of Chauveau's "Anatomy of domesticated animals," that the thalami appear in the lateral ventricles in the horse, ox, pig and dog, and, by implication, all other members of their several groups, should not be accepted without definite descriptions and figures.

Fig. 16.—From preps. 425 and 493. Enlarged two diameters.

This figure shows the *continuity of the procœlia with the rhinocœlia*, and its *communication through the porta with the aula and diacœlia.*

The right half of the brain was transected through the caudal part of the *medicommissura* (*mcs.*). A slice was then cut from the mesal aspect so as to include the *genu.* This exposed the *præcornu* (*prcu.*) with the mesal aspect of the *striatum* (*s.*), the *rhinocœlia* (*rhc.*), and the relative extent of the *pes* (*ps.*), and the *pero* (*po.*) of the *Lobus olfactorius.* A *bristle* was then passed through the *porta* from the præcornu into the *aula* (*a.*). Just ventrad of the bristle are the *præcommissura* (*prcs.*), and the *terma* (*t.*). The latter is traced distinctly to the *chiasma* (*ch.*), so that the cephalic wall of the cœlian cavity is complete. The deeper shadow just dorsad of the chiasma indicates the position of the *Recessus opticus* (*R. op.*).

Just dorsad of the bristle, the *crista* (*Crs. f.*) is seen divided upon the meson, and continuous with the *Columna fornicis* (*Clm. f.*). The indentation between the crista and the præcommissura corresponds with the *Recessus aulæ* (*R. a.*). The triangular *Area septalis* (*Ar. spt.*) between the

fornix and the callosum, is the mesal surface of the right half of the *Septum lucidum* (*Spt. lu.*) and is in contact with its *platetrope* or lateral homologue in the undissected brain. The thickness of the lateral laminæ constituting the septum render the adjective *lucidum* wholly inapplicable.

Fig. 17.—The mesal aspect of the right hemisphere, with the Lobus olfactorius. From prep's 296 and 401.

The caudal divisions of a half-brain were removed, and the thalamus carefully excavated so as to leave undisturbed the *fornix* (*f.*) and the *fimbria* (*fmb.*). In this respect, this figure may be compared with the left half of fig. 14.

The special object of this figure is to show the *F. hypocampæ* (*F. hmp.*), in its whole length at once. So great is the curvature of the parts that this is possible only in a single position of the preparation in which the meson is foreshortened. In general, this figure may be compared with those given by Flower (13) of the rabbit and sheep.

The dorsal end of the *F. hypocampæ* is seen to turn sharply around the *splenium* (*sp.*), so as to become continuous with the *F. callosalis* (*F. cl.*). The *fasciola* (*fscl.*), is wide, and devoid of denticulations, but is crossed obliquely by a shallow furrow. In this position of the preparation, the *F. fimbriæ* (*F. fmb.*), appears to be continuous with a short line passing cephalad to a point ventrad of the callosum; in reality, however, this latter line is only one of the markings of the ventral surface of the fornix, and the *F. fimbriæ*, like the *F. callosalis*, turns sharply dorso-caudad to terminate just cephalad of the splenium.

Fig. 18.—The *right procœlia* seen from the right or ectal side. From prep. 495.

The right half of the brain was removed in successive slices until what remained was about 3 mm. thick. The remainder of the *striatum* was then everted from the *præcornu* (*prcu.*). The *proplexus* (*prpx*) is slightly displaced, but the *porta* is hidden by the *portiplexus* (*ppx.*). The medicornu (*mcu.*), and the *hypocampa* (*hmp.*), are shown in section, and the other parts will be readily recognized. The relative heights of the *opticus* (*op.*), and the *postotpicus* (*pop.*) at a little distance from the meson are well displayed. The short curved line at the cephalo-ventral end of the procœlia represents the beginning of the passage to the rhinocœlia.

Fig. 19.—The *left præcornu* and *porta* exposed from the left or ectal side. From prep. 495.

This figure represents the other side of the same brain as that from which Fig. 19 was drawn. The preparation was made in the same way, but in addition the proplexus and portiplexus were carefully snipped off so as to expose the porta.

The *porta* (*p.*) is seen to open between the *Columnæ fornicis* (*Clm. f.*) and the cephalic end of the *thalamus* (*th.*). The orifice would appear larger if the preparation had been so placed as to leave its plane parallel with the picture-plane.

The membranes could not be shown well on so small a scale. In this and in the previous figure the fornix is seen to be continuous with the *Septum lucidum* (*Spt. lu.*) which forms part of the mesal wall of the *præcornu*.

Fig. 20.—Transection of the *fornix* with the *crista*. From prep. 508.

The object of this figure is to show the decided elevation formed by the *Crista* (*Crs. f.*). Only enough of the rest of the section is included to locate the crista.

LIST OF WORKS AND PAPERS REFERRED TO.*

Barclay, John.—A.—A new anatomical nomenclature, relating to the terms which are expressive of position and aspect in the animal system. O. pp. 182, 5 plates. Edinburgh, 1803.

Chauveau.—A.—Traité d'Anatomie comparée des Animaux domestiques. seconde edition, O., pages 992, 368 figs. Paris, 1871.

Cleland, J.—*1.*—A remarkable double monstrosity of the head. Journ. Anat. and Phys., XIII, 164–172 ; 2 plates. 1879.

Clevenger, S. V.—*3.*—Plan of the Cerebro-spinal nervous system. Read before Am. Assoc. for Adv. Sci., 1880. Jour. of Nerv. and Mental Disease, Oct., 1880. Pp. 40, 26 figures.

Cuvier, G.—A.—Leçons d'Anatomie comparée. 2me edition, 8 vols., D. Paris, 1835–1846.

Dalton, J. C.—*1.*—Cerebral Anatomy, with special reference to the Corpus Striatum. Annals of the Anatomical and Surgical Society, II, 1–18, 6 figures. Jan. 1880. Reprinted in "Brain."

Dunglison, R.—A.—A Dictionary of Medical Science. Large O., pages 1131. Philadelphia, 1874.

Flower, W. H.—13.—On the Commissures of the Cerebral Hemispheres of the Marsupialia and Monotremata as compared with those of Placental mammals. Phil. Trans. clv., 1865, 633–651, 4 plates. Abs. in Roy. Soc. Proc. xiv., 1865, 71–74.

Foster and Langley.—A.—A Course of Elementary Practical Physiology. 3d edition. D., pages 276. London, 1878.

Gegenbaur, C.—A.—The Elements of Comparative Anatomy. Translated from the German by F. J. Bell. Edited by E. R. Lankester. O., pp. 45, 35 figures. London, 1878.

Huxley, T. H.—A.—Manual of the Comparative Anatomy of Vertebrated Animals. D., pages 431, 110 figs. New York, 1872.

———70.—On the Brain of Ateles Paniscus. Zool. Soc. Proc., 1861 ; 247–260 ; 1 plate, 2 figures.

———*1.*—On the Evolution and Classification of Mammals. Zool. Soc. Proc., 1880. Reported in "Nature," Jan. 6 and 13, 1881.

Hyrtl.—A.—Onomatologia, etc. O., pp. 626. Wien, 1880.

Krueg, J.—*2.*—Ueber die Furchen auf der Grosshirnrinde der zono-

* For the manner of reference, see the note at the beginning of this paper.

placentalen Saugethiere. Zeitschrift für wiss. Zoologie, xxxiii, heft 4, 1880.

Leuret et Gratiolet.—A.—Anatomie comparée du systeme nerveux considéré dans ses rapports avec l'intelligence. 2 vols., O., 1284 pages, with folio atlas of 32 plates. Paris, 1839, 1857. (Vol. I is by Leuret, Vol. II, by Gratiolet as stated in a note appended to the explanation of pl. xvii, plates i—xxii were drawn and engraved under the direction of Leuret; but the explanations of xvii–xxii were prepared by Gratiolet according to Leuret's method; the remaining plates were prepared under the direction of Gratiolet.)

Morrell, G. H.—A.—Supplement to the Anatomy of the Mammalia. Containing dissections of sheep's heart and brain, rat, sheep's head, and ox's eye. O., pages 269. London, 1872.

Meynert, T.—A.—The Brain of Mammals. In Stricker's Histology.

———*I.*—Die Windungen der convexen Oberfläche des vorderhirns bei Menschen, Affen und Raubthieren. Archiv für Psychiatrie, etc., vii, 1877.

Mivart, St. George.—A.—The common frog. Nature series, London, 1874. D., pp. 158, 88 figures.

———B.—The Cat; its History, Anatomy, Psychology and Origin, an Introduction to the study of Backboned Animals, especially Mammalia. O, pp. 557, 200 illustrations.

Monro, Alexander, *secundus.*—A.—Observations on the Structure and Functions of the Nervous System. Illustrated with tables. F., pp. 176, 47 plates. Edinburgh, 1783.

Owen, R.—A.—Comparative Anatomy and Physiology of Vertebrates. O., 3 volumes, 2155 pages, 1471 figures. London, 1861, 1868.

Pansch, A.—*I.*—Beiträge zur morphologie des Grosshirns der Saügethiere. Morphologische Jahrbuch, v, 1879.

Quain.—A.—The Elements of Anatomy. 8th edition, 2 vols., O., pages 1530, 1000 figures. London, 1877.

Reichert, C. B.—A.—Der bau des menschlichen Gehirns. Zweite Abtheilung. O., pages 192, 9 plates and 10 figs. Leipzig, 1861.

Rolleston, G.—B.—The Harveian Oration for 1873. D., pp. 90, 4 figures. London, 1878.

Solly, Samuel.—A.—The Human Brain, its Configuration, Structure, Development, and Physiology; illustrated by references to the nervous system in the lower orders of animals. D., pp. 492, 2 figures, 12 plates. London, 1836.

Spitzka, E. C.—*1.*—The central tubular gray. Jour. of Nerv. and Mental Disease; April, 1880; pp. 40.

———*2.*—Notes on the Anatomy of the Encephalon, especially the larger ganglia. "Science," II, 14. Jan. 15, 1881.

———*3.*—The peduncular traits of the Anthropoid apes. Jour. of Nerv. and Mental Disease, pp. 27. July, 1879.

———*4.*—The higher Ganglia of the Mid and Hind Brain. Jour. of Nerv. and Mental Disease. July 1880.

———*5.*—The Brain of the Iguana. Ibidem. Reprinted in "Science," Aug. 14, 1880, 73, 74.

———*6.*—The Architecture and Mechanism of the Brain. Preliminary considerations. Jour. of Nervous and Mental Disease, 1878.

———*7.*—Letter to the Editor on the Nomenclature of the Brain. "Science," April 9, 1881; 165, 166.

———*9.*—Contributions to Encephalic Anatomy, part 10. Jour. of Nervous and Mental Disease, vii, No. 2. April, 1881.

———*10.*—Notes on the Architecture of the Oblongata. N. Y. Med. Jour. and Obstet. Review, Sept. 1881; pp. 10, with one plate.

———*11.*—Some new features of the corpora quadrigemina. The Medical Record, Mar. 13, 1880; 282–284.

———*12.*—Notes on the anatomy of the encephalon, notably of the great ganglia. "Science," Jan. 15, 1881, 14, 15.

———*13.*—Further notes on the brain of the Iguana, and other Sauropoida. "Science," Feb. 19, 1881, 75, 76.

Straus-Durckheim, Hercule.—A.—Anatomie descriptive et comparative du chat, type des mammifères en general, et des carnivores en particulier. 2 volumes, O., 1020 pages, with folio atlas of 25 plates. Paris, 1845.

Vicq d'Azyr.—A.—Traité d'Anatomie et de Physiologie avec des Planches coloriées représentant au Naturel les divers Organes de l'Homme et des Animaux. F., p. 1. Paris, 1786.

Wilder, Burt G.—11.—The outer cerebral fissures of Mammalia (especially the Carnivora) and the limits of their homology. Amer. Assoc. Proc., xxii, 1873, 214–234, 19 figures.

———12.—Cerebral variation in domestic dogs and its bearing upon scientific phrenology. Amer. Assoc. Proc., xxii, 1873, 234–249, 7 figures.

———17.—The need of a uniform position for anatomical figures. Amer. Assoc. Proc., xxii, 1873, 274.

———*2.*—The anatomical uses of the cat. N. Y. Med. Jour., Oct. 1879, pp. 16.

———*3.*—The foramina of Monro: some questions of anatomical history. Boston Med. Surg. Journal. CIII., Aug. 12, 1880. 2 pages.

———*4.*—Notes on the anatomy of the cat's brain. Read at the meeting of the Amer. Assoc. Adv. Science, 1879.

———*5.*—On the foramina of Monro in man and the domestic cat. Read at the meeting of the Amer. Assoc. Adv. Science, 1880. Partly reported in the Boston Daily Advertiser, Aug. 30, 1880. The N. Y. Medical Record, Sept. 18, 1880.

———*6.*—A partial revision of the nomenclature of the brain. (Same as No. 6.)

———*7.*—On the Crista fornicis, a part of the mammalian brain, apparently unobserved hitherto. (Same as No. 6.)

———*8.*—The cerebral fissures of the domestic cat, *Felis domestica*. "Science," I, No. 5, 49–51; 2 figures. July 31, 1880.

———*9.*—A partial revision of anatomical Nomenclature, with especial

reference to that of the brain. "Science," II, No. 38, 122–126, No. 39, 133, 138. Mar. 19 and 26, 1881.

———*10.*—The two kinds of vivisection, sentisection and callisection. Medical Record, Aug. 21, 1880, 219. Reprinted in "Nature," Sept. 30, 1880, and in "Science," Oct. 23, 210.

———*11.*—How to obtain the brain of the cat. "Science," II, No. 41, April 9, 1881, 158–161.

———*12.*—Criticism of Spitzka's "Notes on the anatomy of the encephalon. etc." "Science," No. 31, p. 48, Jan. 29, 1881. (Embodies a statement of opinion as to the dorsal limits of the diacœlia.)

———*13.*—On the brain of a cat lacking the corpus callosum. (Presented at the meeting of the Amer. Assoc., 1879, but not yet published.)

Williams, H. S.—A.—The bones, ligaments and muscles of the domestic cat. O., pp. 86; with atlas of 12 folio plates. Copies, reduced one-third, of the outline plates in Straus-Durckheim's A. The text is an explanatory index. New York, 1875.

Addenda.—Concerning the morphical relations and significance of the *conarium* and the *hypophysis*, see the paper by Prof. Owen, read before the British Association in 1881, and reported in "Nature" for Sept. 22, 1881.

In his Report for 1880, as Entomologist of the U. S. Dept. of Agriculture, my colleague, Prof. J. Henry Comstock, expresses (p. 284) his approval of most of the toponomical terms proposed in the present paper (p. 531) and employs them in the descriptions of insects therein contained.

Stated Meeting, November 4, 1881.

Present, 12 members and 7 visitors.

President, Mr. FRALEY, in the Chair.

Mr. Barbour a newly-elected member was introduced to the President, and took his seat.

Letters accepting membership were received from Mr. Charles J. Jones, Jr., dated Augusta, Georgia, October 26; from Mr. Jedediah Hotchkiss, dated Staunton, Virginia, October 31; from Prof. C. L. Doolittle, dated South Bethlehem, Pennsylvania, October 28, and from Prof. Mansfield Merriman, dated Bethlehem, Pennsylvania, October 25.

Letters of acknowledgment were received from the Physical

Society, Berlin (103–105); the K. L. C. German Academy, Halle (sets of Transactions and Proceedings); the Prague Observatory (XVIII, 107); Offenbach Verein (XVIII, 107); Physical Society, Geneva (102–105); Swiss Society, Bern (102–105); Royal Society, Luxembourg (103–105, 106, 107, List); Royal Society, London (105, 106, List); Victoria Institute (107, 108); Literary and Philosophical Society, Liverpool (106, List).

Letters of envoy were received from the Physical Society, Berlin; Saxon Society, Leipsig; L. C. Academy, Halle; Swiss Society, Bern; Physical Society, Geneva, Musée Guimet, Lyons; Zoological Society, Paris; Geological Survey of India; and Department of the Interior, Washington.

Donations to the Library were received from the Academies at Halle and Brussels; the Com. Geog. Society, Bordeaux; Annales des Mines; Revue Politique; London Royal, Zoological, Geographical, Geological, Meteorological and Asiatic Societies, and Nature; Mr. Sanford Fleming; the Canadian Journal; Dr. Green of Groton; Silliman's Journal; New Jersey Historical Society; Medical News; A. R. Spofford of Baltimore, and the U. S. Department of the Interior.

Dr. Ruschenberger declined by letter his appointment to prepare an obituary notice of the late Dr. B. H. Coates, on account of his engagements.

Dr. Brinton communicated by letter a paper "On the names of the gods in the Kiche myths," the reading of which was postponed to the next meeting.

"The paper is an exegetical study of the celebrated myth of the Kiche tribe of Guatemala, known as *Popol Vuh*, or National Book. The original dates from the latter half of the XVI century, and was first published in Paris by the Abbé Brasseur de Bourbourg in 1861. The facilities I have had for its study have been principally the MSS. grammars and dictionaries of the Guatemalan tongues presented to the Society by Señor Mariano Galvez, President of Guatemala, in 1836. Their use has thrown new and important light on the significance and character of this myth; and, as these MSS. have never been published, I have given numerous full extracts from them. The treasures of the Library of the Society will thus be brought to the knowledge of students."

PROC. AMER. PHILOS. SOC. XIX. 109. 3s. PRINTED DEC. 31, 1881.

Dr. Newberry communicated, by letter, of October 27th, a paper "On the Origin and Drainage of the Great Lakes," the reading of which was postponed to the next meeting.*

Dr. E. R. Heath, present by invitation, was then presented by Prof. Cope to the President, and requested to describe the manner and results of his recent exploration of the river Bene, and the hitherto unexplored regions of Bolivia, lying to the south-west of the railroad now being built alongside of the rapids of the Madeira river.

Dr. Heath exhibited a wall map of the north-east course of the Bene river through the great periodically inundated plains, which stretch between the east foot hills of the Andes, and the mountains of Brazil, down to its junction with the Mamora (coming from the south) to form the Madeira.

He exhibited also a collated map of the water system of the Upper Madeira waters, and described the corrections necessary to be made on the published maps of Bolivia.

He described the vast forests of rubber and Brazil nut trees—trees of 200′ height when mature—the pampas, scattered over with shrubs like our scrub-oaks—the channel of the Bene, straight as a whole, but tortuous in detail, with alluvial banks, about 30 feet high, over or through which, every year, the inundation spreads over the whole country, leaving here and there dry spots on which the Brazil nut grows—the solitary obstacle to navigation, in the shape of low gneissoid rocks, not far above its junction with the Madeira—and the commerce in gold, silver, copper, tin, fine coffee, cocoa, vanilla, caoutchouc, Brazil nuts, cattle, &c., which will some day flourish, by the natural route of the Bene, Madeira and Amazons, opening up Bolivia to the civilized world.

For 800 miles the Bene is navigable, without interruption, by steamboats drawing 5 feet of water.

Dr. Heath described the various tribes of the country; one, as white as Europeans, and another addicted to cannibalism, and greatly dreaded along the river, on account of their occasional raids for the purpose of securing victims. Neighboring tribes present the most diverse facies. In one district a tribe of small men adjoin a tribe of very tall full-bodied men, and next to these live a tribe of tall, meagre and cadaverous men. All three of these tribes speak different languages. Dr. Heath intends to make a comparative study of his copious linguistic notes.

He exhibited several sheets on which were his drawings of some of the very numerous symbols, or picture writing, which have been cut, to a depth of about an inch, probably by the architectural race of Cuzco and late Titicaca, on all the rocks in and alongside of the river channels, in the district around the great forks of the Madeira. He believed these inscrip-

* This paper will be printed in Vol. xx, No. 111.

tions to relate to the navigation of the river, because of their situations above, below or at the water level, during the various stages of low. middle or high water. Wherever they occurred at dangerous points, he noticed that duplicates were cut so as to face both descending and ascending boats, and the relation of certain marks to safe low water at such and such a point was evident.

It is probable then that the Bene was used in the pre-Spanish age by the race which has left its noble monuments not only on the plateau between the two Andean ranges, but in the ravines by which the head waters and branches of the Madre de Dios and Bene descend into the plain. He could not find, nor hear of, any architectural remains on the plain itself; but he was informed that a "fort" stood on an island in a lake which occupies part of the triangle between the Bene on the northwest and the Mamora on the east.

The plain itself is astonishingly level, the upper reaches of the Bene being only 600 or 700 feet above sea level. [In giving his own exact determination from observations with the mercurial barometer (and supplementary aneroids) extended through three years at El Paz, he remarked on the falsity of former determinations made during transient stops in the country; one well known point being put variously from 170 feet *below*, to 1700 feet *above* tide. This he explained was due to the fact that while the mercurial column is not subject to ordinary fluctuations, and seems for weeks at a time to be quite or almost stationary, there is really a steady cyclical rise for six months, and a corresponding steady fall for the other six months of each year, and this must be taken as the basis of all meterological and hypsometrical investigations].

Dr. Heath then described in a general way the zoölogical features of the region; the abundance of (harmless) alligators in the rivers; the absence of snakes from the forest plain of inundation, and their presence along the margin of the dry districts; the wasp-like severity of the bite of the ticks in the forests; the irritation produced by the abundance of parasitic insects on the pampas; the incredible abundance of bats in the houses, and their thirst for animal and human blood; the numerous species of monkeys; the large size of the cattle of the country south of the Bolivian (east and west) divide; the change in the voices of birds from harsh in the mountain regions to melodious on the plain; the anvil bird (tree toad?); the organ bird with its diatonic scale of eight ascending notes; the change of the plumage of paroquets from brilliant varied hues in the northern districts, to a general pale green in the southern; the abundance of struthious birds, and the incredible quantity of ant hills in the dry country.

After various questions asked by the members and visitors present, and answered by Dr. Heath, it was, on motion

Resolved, That the thanks of the Society be tendered to Dr. Heath for his very interesting and important communication.

Prof. Chase then made a short communication, placing data on the blackboard, to support a further enlargement of the range of applications of his photodynamic theory to natural phenomena;—and the meeting was adjourned.

Stated Meeting, November 18, 1881.

Present, 11 members.

President, Mr. FRALEY, in the Chair.

Mr. Sharpless accepted membership by letter, dated West Chester, October 29, 1881.

The Cincinnati Observatory acknowledged receipt of Proceedings No. 108.

The Chapultepec Observatory of Mexico requesting exchanges, was placed on the list of correspondents to receive the Proceedings regularly.

Donations for the Library were received from the Royal Society of Tasmania; the Geological Survey of India; Imperial Academy at St. Petersburg; German Geological Society and Society of Physics, Berlin; Natural Science Union, Bremen; Neues Lausitzisches Magazin, Görlitz; Royal Saxon Society, Fürstliche Jablonowskischen Gesellschaft, and Zoologischer Anzeiger, Leipsig; Royal Grand Ducal Institute, Luxembourg; Society of Physics, Geneva; Vaudoise Society, Lausanne; Swiss Society; Anthropological Society, Zoological Society, and Revue Politique, Paris; Revista Euskara, Pamplona; Nature, London; Royal Irish Academy, Dublin; Essex Institute, Salem; Boston Natural History Society; Museum of Comparative Zoology, Cambridge; Mr. Aug. R. Grote, Buffalo; Pharmaceutical Association, Historical Society, Franklin Institute, and the Editor of the American News, Philadelphia; Department of the Interior, and W. J. Hoffman, M. D., Washington; Astronomical Observatory of Chapultepec; Geographical and Statistical Society; Editors of

the Revista Mensual Climatologica, and the Revista Cientifica Mexicana, and the Ministerio de Fomento, Mexico.

An obituary notice of the late Wm. E. DuBois, was, by appointment, read by Mr. Robert Patterson.*

Dr. Brinton explained to the Society the substance of his paper on the Gods in the Kiché Myth, the Popol Vuh.

Mr. Lesley read Dr. Newberry's paper on the Origin of the Lake Basins, and then remarked on the relation of Dr. Newberry's claims to Prof. Spencer's discoveries and views.†

Mr. Lesley gave a short sketch of the history and progress of the excavations at Assos during the last few months, under the auspices of the Boston Archæological Society, as he obtained it in conversations with Prof. W. R. Ware of Columbia College.

The minutes of the last meeting of the Board of Officers and members in Council were read, and the consideration of the resolution therein was postponed for the next meeting.

Certain valuable manuscripts were ordered, on motion of Dr. Brinton, to be placed by the Library Committee in the custody of the Fidelity for safe keeping.

Pending nomination No. 935, and new nominations Nos. 946 to 950 were read, and the meeting was adjourned.

Photodynamic Notes, IV. By Pliny Earle Chase, LL.D.

(Read before the American Philosophical Society, November 4, 1881.)

91. *Photodynamic Determination of Sun's Mass and Distance.*

In Notes 5 and 23, I estimated Sun's mass both from projectile and from simple oscillatory considerations. In the former note I deduced the distance from an assumed solar density, instead of taking the ratio of variability $d^3 \propto mt^2$. My conviction of the importance of Fourier's theorem has been strengthened by further study, and I accordingly give, in the present note, the coördinate photodynamic elements which may be simply deduced from it.

If we regard the luminiferous æther as a nebulous elastic atmosphere, and the solar system as a partially condensed nebula, the nebula is not homogeneous. It contains, in addition to various subordinate and com-

* This paper will be printed in Vol. xx, No. 111.

† Dr. Newberry's paper will be printed in Vol. xx, No. 111.

paratively unimportant nuclei, two principal and controlling nuclei of nearly equal density, viz.: Sun, at the principal centre of nucleation, and Jupiter at the mean nebular centre between Uranus at apojove, and Neptune at perijove.

The actions and reactions between these controlling nuclei have produced an intermediate maximum condensation in the belt of dense planets, with a principal mass, Earth, near the centre of the belt. The solar radiations are propagated with the velocity of light, v_λ. If we designate Earth's mass by m_3, the actions and reactions of photodynamic *vis viva* at the centre of density, $m_3 v_\lambda^2$, produce gravitating tendencies towards the linear centre of gravity ($\frac{1}{2}$), the centre of linear oscillation ($\frac{1}{4}$), and the centre of conical oscillation ($\frac{1}{4}$), which vary as the fourth power* of the tendencies to orbital velocity. These tendencies are all satisfied by a reacting mass, $m_3 = (\frac{1}{2} \times \frac{1}{2} \times \frac{1}{4})^4 m_0 = \frac{1}{3\,3\,3\,1\,7\,7\,8}$ of Sun's mass. The photodynamic character of the oscillatory *vis viva* at the centre of condensation is shown by the following proportions:

$$(1) \qquad m_0 v_0^2 : m_3 v_\lambda^2 :: m_3 v_\lambda^2 : m_3 v_0^2$$

$$(2) \qquad v_\lambda : v_0 :: v_0 : v_n$$

$$(3) \qquad v_n^4 : v_3^4 :: p_3 : p_0$$

In these proportions m_0 is taken as the unit of mass; Jupiter's mass, $m_3 = \frac{1}{1\,0\,4\,7.8\,7\,8}$; v_n = orbital velocity at centre of condensation: v_0 is a mean proportional between v_λ and v_n; p_0 = ratio of mean photodynamic projection of Sun's centre from the centre of gravity of Sun and Jupiter, Sun's semi-diameter being the unit; p_3 = mean photodynamic projection of the centre of condensation from Earth's semi-axis major as a unit; these projections, like the gravitating tendencies, vary as the fourth power of orbital velocity.

If we take $t_\lambda = 497.827$ seconds, and $g = 32.088$ feet, the above proportions give

$v_\lambda =$	186381.4	miles =	299943.5	kilometres.
$v_0 =$	1841.017	" =	2962.75	"
$v_n =$	18.185	" =	29.265	"
$v_3 =$	18.4735	" =	29.729	"
$p_3 =$	1.015866.			
$p_0 =$	1.06499.†			
$\rho_3 =$	92785700	miles =	149320000	kilometers.
$r_0 =$	432574.9	" =	696143.3	"

$n = \rho_3 \div r_0 = 214.496.$

Sun's parallax = 8″.8094.

* $g \propto \frac{1}{d^2}$; $v = \sqrt{gr} \propto \sqrt{\frac{1}{d}}$; $\therefore g \propto v^4$.

† Stockwell's estimate (*Smithsonian Contrib.*, 232, p. 38), is $\frac{1}{9\,5\,9\,1\,7\,2\,6} = 1.06467\ r_0$.

92. *Latent Heat of Steam.*

The maintenance of the primitive velocity of undulation is exemplified in the relation between the projectile energy of evaporation and the energy of solar rotation. The equatorial velocity of solar rotation is $\frac{\pi g_\circ r_\circ}{v_\lambda}$. The mean rotating velocity of the locus of the centre of gravity of Sun and Jupiter is, therefore, $v_p = \frac{p_\circ \pi g_\circ r_\circ}{v_\lambda}$. The centre of gravity itself does not rotate, but its action produces æthereal photodynamic undulations, which are propagated with the velocity v_p, *which is equivalent to the projectile velocity of evaporation*, v_s;

$$v_p = v_s.$$

This equation is so important that it may be well to give the calculation in full:

$m_\circ \div m_3 = (2 \times 3 \times 4)^4 = 331776$	5.5208450
1 year $= 31558149$ seconds $= t_1$	7.4991115
$t_3 = 2\pi \sqrt{\frac{r_3 = 3962.8 \text{ miles}}{g_3 = 32.088 \text{ feet}}} \doteq 5073.6$ seconds	3.7053158
$\nu = \rho_3 \div r_3 = \left(\frac{t_1^2 m_\circ}{t_3^2 m_3}\right)^{\frac{1}{3}} \doteq 23414.2$	4.3694788
$\rho_3 = \nu r_3 \doteq 92{,}785{,}700$ miles	7.9674810
$v_\circ = v_\lambda = \rho_3 \div 497.827 \doteq 186381.4$ miles	5.2704025
$p_3 = 1.015866$	.0068364
$p_\circ = p_3^4 = 1.06499$	.0273455
$\rho_5 = (p_\circ m_\circ \div m_\varepsilon) r_\circ = 1.06499 \times 1047.879\, r_\circ \doteq 1115.98\, r_\circ$	3.0476566
$n = \rho_5 \div 5.202796\, r_\circ \doteq 214.496$	2.3314197
$r_\circ = \rho_3 \div n \doteq 432574.9$ miles	5.6360613
$\sqrt{g_\circ r_\circ} = 2\pi n^{\frac{3}{2}} r_\circ \div t_1 \doteq 270.557$ miles	2.4322592
$\therefore v_p \doteq v_s \doteq 1.31405$ miles	.1186113

From this equation the latent heat of steam, θ, can be readily found, by the equations

$$v_s = \sqrt{2gh}$$

$$\theta = \frac{h}{1389.6}$$

Solving these equations we get

$h \doteq 142.064$ miles $\doteq 750098$ feet	5.8751178
$\theta \doteq 539°.794$ C	2.7322280

The following values of θ have been deduced experimentally:

Favre and Silbermann	535°.77
Andrews	535°.90
Regnault	536°.67
Tyndall	537°.20
Despretz	540°.00
Dulong	543°.00

93. *Internal Energy of Ice.*

According to the kinetic theory of gases, the internal movements of the particles of steam are rectilinear, representing a total *vis viva* of projection, against the uniform resistance of gravity, of about $\frac{1}{2} \times 1389.6\ \theta$ feet $\doteq$ 189.42 miles. While the steam is condensed in the form of water or ice, the internal energies tend to maintain a spherical figure. The resultant oscillations (Note 23), can therefore be represented by a conical pendulum of $\frac{1}{4}$ the height of total projection, or $\frac{1}{8}$ of the projectile *vis viva* of evaporation. This gives, for the virtual fall from incipient ebullition to total congelation, $h_1 = \frac{1}{8} h \doteq 47.355$ miles $\doteq 250033$ feet; and for the heat of sphericity $\theta_1 = \frac{1}{8}\theta \doteq 179°.931$ C. Deducting 100° for the expansion from the freezing to the boiling point, we have 79°.931 for the "latent heat" of ice, or the heat which is required to overcome its internal energy. The following values have been deduced experimentally:

Desains and De la Provostaye	79°.25
Black	79°.44
Person	80°.00
Hess	80°.34

94. *Photodynamic Moment of Inertia.*

Much of the difficulty which has been encountered in trying to reconcile the nebular hypothesis with actual planetary arrangements, has arisen from overlooking the difference between nucleal retardation and free orbital revolution. Herschel's doctrine of "subsidence" removes this difficulty, and an examination of the primitive planetary belt, before any of its successive divisions into asteroidal and intra-asteroidal belts, two-planet belts, and single-planet belts, shows the photodynamic influence in a very striking manner. The limit of photodynamic *nucleal* rotation is in the asteroidal belt; the photodynamic limit of "subsidence" rotation is at the solar modulus of light. I have often shown* that Saturn represents the photodynamic centre of inertial moment; in the division of inertia among the several belts, provision has been made for the change of linear into synchronous conical oscillations (4 : 1); for the change of synchronous into orbital oscillations ($t \propto l^{\frac{3}{2}}$); for the ratio of nebular radii to radii of subsidence-collision ($\frac{4}{3}$); and for the relative variability of centripetal and orbital tendencies, ($g \propto v_s^4$). Hence we find

$$4^{\frac{3}{2}} \times (\tfrac{4}{3})^4 \times M_\odot : m_6 :: V_\odot : v_s$$

Substituting the values of $V_\odot$ and v_s (Note 92) we get

$$M_\odot = 3502.2\ m_6.$$

Bessel's estimate was 3501.6.

95. *Photodynamic Centres of Gravity.*

An interesting approximation is shown by the ratio

$$3^3 \times 5 \times M_\odot : m_5 :: V_\odot : v_3.$$

* Note 12; *ante*, xviii, 431; *et al.*

The ratio of the foregoing note may be expressed as follows:

$$3^4 M_\circ : 2 m_6 :: V_\circ : v_3.$$

Combining these ratios we get

$$3 m_3 = 10 m_6.$$

The repetition of the pendulum-ratio, and the simplicity of the harmonic factors make these ratios so suggestive that they seem worthy of further study.

96. *Universal Energy of Light.*

It may be well to state the principal facts which are embodied in notes 90-95, in such a way as to show more clearly the simplicity of the relations of the several physical velocities to the velocity of solar radiation.

1. $\dfrac{v_\lambda}{u_3} = \dfrac{h_\circ}{h_1} = \dfrac{M_\circ}{m_3} = \left(\dfrac{t_n}{t_a}\right)^2 \times \sqrt{\dfrac{\varphi_\circ}{\varphi_3}}$

2. $\dfrac{v_\lambda}{v_3} = \dfrac{\sqrt{M_\circ m_3}}{m_3} = \dfrac{M_\circ t_a}{m_3 t_n} \times \sqrt{\dfrac{\mu}{\chi}}$

3. $\dfrac{v_\lambda}{v_a} = \dfrac{3^4 M_\circ}{2 m_6}$

4. $v_\lambda v_r = v_\circ^2 \times \dfrac{t_n}{t_a}$

5. $v_a = v_p$ (Note 92)

6. $v_\lambda = g_\circ t_\circ$.

In these equations, v_r = velocity of equatorial rotation which Sun would have if it were expanded to the locus of a particle which revolves with the circular-orbital velocity $v_\circ$; by the law of conservation of areas v_r varies inversely as radius, while $v_\circ$ varies inversely as the square root of radius; v_3 = Earth's orbital velocity.

If we assume $M_\circ = 328470 m_3$, we find $h_\circ = 92476500$ miles; $v_\lambda = 185760$ miles; $v_3 = 18.412$ miles; $u_3 = 2986$ ft.; $v_a = 6916.2$ ft. The following table shows the accordance between theoretical and observed values:

	Theoretical.	Observed.
1. Boiling point,	99.°98	100°
Combining heat of H_2O,	69319	67616. to 69584*
$\varphi_\circ$	140.65	140 lbs. per sq. in.
2. v_3	18.31	18.41
$\chi \div \mu$	107.38	106.67
3. Latent heat of steam,	536.°374	536.°385†

In these comparisons I have made no allowance for the photodynamic projections which have caused orbital eccentricities, as it may be pre-

* See Note 16.

† Mean of first four estimates in Note 92.

sumed that they have affected different elements in different ways and to different degrees. I still think that the true value of M_0 is about one per cent. greater, and the value of h_0 about $\frac{1}{4}$ of one per cent. greater than here given.

Weber and Kohlrausch demonstrated the importance of photic velocity in electromotive energy, by measuring quantity of electricity; Thomson and Maxwell, by measuring electromotive force; Ayrton and Perry, by measuring electrostatic capacity.

97. *Maximum Density of Water.*

If we let u_4 represent the potential velocity of water at its greatest density, we find that the greatest known velocity of æthereal wave-propagation : the greatest known gravitating velocity : : the corresponding circular-orbital velocity : the potential velocity of water at its greatest density.

$$v_\lambda : v_0 \sqrt{2} : : v_0 : u_4 \qquad (1)$$

Let $\theta = 100°$ C. — water-temperature of maximum density; $\rho_3 =$ Earth's semi-axis major $= nr_0$; $r_0 =$ Sun's semi-diameter. Then

$$v_\lambda = \rho_3 \div 497.827 \qquad (2)$$

$$v_0 = n^{\frac{1}{2}} \times 2\pi\rho_3 \div 1 \text{ year in seconds} \qquad (3)$$

$$u_4 = \sqrt{2gh} = \sqrt{2g\theta \times 1389.6 \div 5280} \qquad (4)$$

If we substitute (2), (3) and (4) in (1), and adopt the British Nautical Almanac estimate, $n = 214.45$, the most satisfactory experimental determinations of θ give the following results:

Authorities.	θ	u_4	ρ_3
C. Von Neumann	96°.32	.55508 miles.	92,746,800 miles.
Plücker and Geissler	96.20	.55473 "	92,689,100 "
G. Hagen	96.13	.55453 "	92,655,300 "
Joule and Playfair	96.055	.55432 "	92,619,200 "
F. Exner	96.055	.55432 "	92,619,200 "
Despretz	96.00	.55416 "	92,592,700 "
F. Rossetti	95.93	.55396 "	92,558,900 "
H. Kopp	95.92	.55393 "	92,554,100 "
Mean	96.076	.55438 "	92,629,300 "

Whatever value may be adopted for Sun's apparent semi-diameter and for θ, the corresponding value for Earth's semi-axis major may be readily found, since $\rho_3 \propto \sqrt{\frac{\theta}{n}}$.

98. *Electric Mass.*

Many of the foregoing relations seem to show that if the factor M, in electric dimensions, has any proper analogy to the mass-factor in ordinary energy, it should be referred to the particles, or the most minute ap-

preciable portions of luminiferous æther. Professor S. P. Thompson, in the Philosophical Magazine for July, 1881,* makes the following noteworthy suggestion:

"Matter has dimensions [M], Energy [ML^2T^{-2}], and Electricity $\left[M^{\frac{1}{2}} L^{\frac{3}{2}} T^{-1}\right]$. The latter value is obtained from a consideration of the Law of Coulomb, that $Q \times Q \div L^2 = \text{force} = \left[ML\,T^{-2}\right]$; whence

$$Q = \left[(ML^3T^{-2})^{\frac{1}{2}}\right].$$

But the dimensions of self-attractive matter may be similarly considered by Newton's Law that $-M.M \div L^2 = \text{force} = [M\,L\,T^{-2}]$, whence

$$M = [-L^3\,T^{-2}].$$

And if this value be put in place of M in the dimensions of Q above, we get $Q = \left[\sqrt{-1}\,(L^3\,T^{-2})\right]$, a quantity whose dimensions differ only from those of M in being prefixed by the imaginary quantity $\sqrt{-1}$. This seems to indicate an important relation."

99. *Change of State.*

In the Philosophical Magazine for July, 1881, Professor J. H. Poynting discusses "Change of State; Solid-Liquid." He shows that it follows from his "mode of regarding the subject, that, if in any way the ice can be subjected to pressure while the water in contact with it is not so subjected, then the lowering of the melting point per atmosphere is about $11\frac{1}{2}$ times as great as when both are compressed" (p. 34). In Herschel's hypothesis of nebular "subsidence" a similar action is implied, the nebulous or æthereal atmosphere corresponding to the uncompressed water, and the subsiding particles, under the gravitating pressure, corresponding to the compressed ice. In a former study of potential energy (Proc. Soc. Phil. Amer., xvii, 98), I showed that, under such circumstances, "the increase of radial velocity would be sufficient to produce orbital velocity in the periphery of a stationary nebula, when $\sqrt{n} = \sqrt{2}\,(\sqrt{n}-1)$, and $n = \frac{2}{3-2\sqrt{2}} = 11.656854$." The important bearing of this relation upon planetary positions was also shown at the same time.

100. *Earth's Photodynamic Condensation.*

Let t_λ = time in which solar superficial gravitation would communicate the velocity of light, or time of solar half-rotation; t_5 = Jupiter's orbital time; r_3 = Earth's semi-diameter; r_s = 338.2183 r_3 = Earth's synchronous radius, or distance at which a particle would revolve about Earth, synchronously with Earth's revolution about Sun,

Then $$r_s : r_3 :: t_5 : t_\lambda.$$

This gives 12.81 days for t_λ, or 25.62 days for Sun's rotation, which is $\frac{1}{2}$

*Foot-note page 17.

of one per cent. greater than Laplace's estimate and than the mean value which is indicated by other photodynamic considerations.

101. *Earth's Rigidity.*

Sir William Thomson concluded, from investigations of tidal action and equinoctial precession, that "the earth as a whole is much more rigid than any of the rocks that constitute its upper crust," and that the mean tidal effective rigidity must be greater than that of glass. The inconsistency of this hypothesis with the belief of the internal fluidity of the earth led many to question it. Gen. J. G. Barnard (Smithsonian Contributions, 240) applied the principles of the gyroscope to the explanation of precession, and endeavored to show that no increase in the rate of precession arises from fluidity. Thomson subsequently modified his views (Brit. Assoc. Rep., 1876) in accordance with his theory of vortex-atoms, by considerations based on the quasi-rigidity introduced into a liquid by vortex motion. The stress of the æthereal waves must have an important influence both upon the gyroscopic and upon the vortical tendencies, and the rapidity with which they are propagated may perhaps furnish the substitute for the inconceivable rigidity which seemed to be required in the first discussion of the problem.

102. *Sun's Internal Temperature.*

In Note 58, I gave two photodynamic estimates of solar temperature, the second being 3.07 per cent. greater than the first. The second estimate was based on the hypothesis that the whole mass of the Sun is either fluid or gaseous, so that every particle is continually yielding to tendencies toward Sun's centre, toward the centre of gravity of the solar system and toward the immediate centre of gravity. If the whole mass could be collected at Sun's centre, it would revolve about the centre of gravity of the solar system in less than three hours, but the rotation on the axis which partially compensates for the tendency to revolution, requires about 25.5 days. The orbital motion of the Sun about the centre of its stellar system furnishes a slight additional compensation, but the photodynamic stress seems to be mainly represented by radial oscillations which are synchronous with the orbital revolution which Sun's centre would have if it were free. The potential velocity which represents such radial oscillations, is that which would be acquired by vertical fall through half of the diameter, or perihelion parabolic velocity.

103. *Earth's Internal Temperature.*

The small mass of Earth interposes little opposition to orbital tendencies, and its greatest velocity of axial rotation is only about $\frac{1}{0\,4}$ as great as its solar orbital velocity. If Earth's whole mass was homogeneous, gravity within its mass would vary as distance from centre, and the *mean* tendency to orbital velocity, in reaction against the stress of æthereal undulations, would be represented by a virtual fall through $\frac{1}{4}$ of radius, or 990.7 miles.

This represents a thermal energy of $990.7 \times 5280 \div 1389.6 = 3764.32$ calories, which would be communicated by a temperature of 3764°.32 C., or 6775°.78 F. The temperature of melting rock is estimated by Sir William Thomson (Thomson and Tait's Natural Philosophy, i, App. D., p. 716) at 7000° F. Notwithstanding the crudeness of this approximation, it shows that the temperature which represents orbital reactions against æthereal stress is of the same order of magnitude as that of melted rock, thus corroborating other evidence of the probable fluid condition of the greater portion of our globe.

104. *Barometric Strain.*

The evidence which I presented in 1863 (Proc. Soc. Phil. Amer., ix, 283-8), of cyclical atmospheric strains resulting from the combined stresses of pressure, inertia and elasticity, presents an interesting problem for mathematical analysis. I confined myself to an investigation of mere numerical results; in generalizing and extending them, the following FACTS seem most important:

1. The atmospheric daily variation of solar or terrestrial centripetal inertia is comparatively insignificant.

2. The variation of tangential orbital motion, between noon and midnight, is about $\frac{1}{1\,2}$ of the mean motion; the consequent variation in the moment of inertia is about $\frac{1}{6}$ of the mean moment.

3. The orbital moment of inertia is more than 4000 times as great as the equatorial rotary moment.

4. The combined influences of elasticity and orbital moment of inertia tend to drive the atmospheric particles away from the Earth during the first and third quarters of the day, and towards the Earth during the second and fourth quarters.

5. The sum of the instantaneously varying tendencies reaches a maximum in the middle of each quarter.

6. The ratio of the mean equatorial daily variation of the barometer (above or below its mean altitude), to its mean altitude, corresponds very closely to the ratio of equatorial daily rotation (24,895 miles) to the sum of Earth's synodic daily gravitating reactions against Sun's gravitating action ($86400^2 \times 16.044 \div 5280 = 22683300$ miles).

7. The time of maximum disturbance in each quarter of the day, is delayed about an hour after the middle of the quarter at tropical stations.

8. The magnitude of the disturbances in the morning and afternoon is increased by the atmospheric expansion which is due to solar heat.

9. The magnitude of the disturbances during the night is diminished in such proportion as to maintain the *average* quarter-daily change, which is required by the actions and reactions of elasticity and inertia.

10. The tendency to description of equal areas in equal times, leads approximately to the proportion, especially within the tropics,

$$e^2 : e_1^2 :: r : r_1.$$

In this proportion e represents the daily barometric range; e_1, the annual

range; r, the virtual radius of daily inertia, $86400^2\, g \div 2$; r_1, the radius of annual inertia, Earth's semi-axis major.

105. *The St. Helena Test.*

The most extensive and satisfactory intertropical observations that appear to have been published, are those of Gen. Sabine, at St. Helena, in latitude 15°57′S. Ganot's formula, $g = 32.174\,(1 - .00256 \cos. 2\varphi)$, gives $g = 32.104$, and $r = 86400^2 \times 16.052 \div 5280 = 22394600$ miles. The mean of five years' observation gives $e = .067$ in.; $e_1 = .135$ in.; $r_1 = \frac{e_1^2\, r}{e^2} = 92138400$ miles. This differs by less than $\frac{3}{4}$ of one per cent. from the greatest value that seems likely to result from the final discussion of the observations of the last transit of Venus, and by less than $\frac{1}{4}$ of one per cent. from the result that has been indicated by some of the recent English discussions. The simplicity of this relation, in the case of our planet, is perhaps due partly to Earth's position at the centre of condensation in the solar system.

106. *Gaseous Diffusion.*

Doebereiner, in his researches on spongy platinum, accidentally used a jar which had a slight crack or fissure. He was surprised to find that the water of the pneumatic trough rose into the jar two and two-third inches in twenty-four hours, although there had been no sensible change in the height of the barometer or the heat of the room. This observation led Graham (*Chemical and Physical Researches*, p. 44; *Phil. Mag.*, and *Pogg. Ann.*, 1833), to the experiment from which he deduced his law of gaseous diffusion: "The diffusion or spontaneous intermixture of two gases in contact is effected by an interchange in position of indefinitely minute volumes of the gases, which volumes are not necessarily of equal magnitude, being, in the case of each gas, inversely proportional to the square root of the density of that gas." He subsequently (*Researches*, p. 88; *Phil. Trans.* 1846, 1849), showed that this was a result of diffusive velocities varying "inversely as the square root of their densities," referring also to "the theoretical law of the passage of gases into a vacuum, according to the well-known theorem that the molecules of a gas rush into a vacuum with the velocity they would acquire by falling from the summit of an atmosphere of the gas of the same density throughout; while the height of such an atmosphere, composed of different gases, is inversely as their specific gravities. This is a particular case of the general law of the movement of fluids, well established by observation for liquids, and extended by analogy to gases." These views involve all the consequences of equality of *vis viva*, in chemical as well as physical actions and reactions, and they indicate the direction in which we may still look hopefully for an extension of our knowledge of chemical physics.

107. *Kinetic and Static Energies.*

Motions, or tendencies to motion, v_1, in elliptical orbits, vary in the inverse ratio of the distance from the centre of gravity. The acceleration of a particle by any given mass, g, varies inversely as the square of the distance. Orbital velocity of a particle, v_o, varies inversely as the square root of the distance. Velocity of gaseous diffusion, v_2, varies inversely as the square root of the density, or inversely as orbital time, or inversely as the $\frac{3}{2}$ power of the mean distance.

$$g \propto \frac{1}{r^2} \propto v_o^4$$

$$v_2 \propto \left(\frac{1}{r}\right)^{\frac{3}{2}} \propto v_o^3$$

$$v_1 \propto \frac{1}{r} \propto v_o^2$$

$$v_o \propto \left(\frac{1}{r}\right)^{\frac{1}{2}} \propto v_o$$

These several relations all seem likely to be involved in different problems of chemical physics.

108. *Critical Temperatures.*

Notes 58, 92–7, 102–3, indicate a variety of thermodynamic relations to mass, which may be special instances of a large class. Circular, parabolic, and dissociative velocities introduce the factors $\sqrt{2}$ and π, and temperatures vary as the square roots of their representative velocities. Hence may arise an indefinite number of critical temperatures. The two which immediately follow Earth's theoretical internal temperature, Note 103, are 9582°.4 and 12009°.8 F. These temperatures may, perhaps, have important bearings upon questions of specific heat, and specific and atomic *vis viva*.

109. *Harmonic Spectrum of Arsenic* [*and Thallium*].

The American Journal of Science, for September, 1881, publishes Huntington's Arsenic Spectrum, printing in heavy type "the bands which are most brilliant and give character to the spectrum. The other lines are less constant and less distinct, and in some instances may be due to accidental causes." "Upon examining the spectrum it appeared evident that thallium must be present in the arsenic in large quantities." The relations of the observed lines to lines which are in harmonic progression are shown in the following table.

Wave-Length.		Divisors.	
Harmonic.	Observed.	Harmonic.	Observed.
6023	6023		
6012	6013	$236x = 1.0018$	1.0017
5815	5813	$244x$ 1.0358	1.0361
5653	5653	$251x$ 1.0655	1.0653
5564	5563	$255x$ 1.0825	1.0827
5499	5498	$258x$ 1.0952	1.0955
5334	5340Tl	$266x$ 1.1292	1.1279
5104	5103	$278x$ 1.1801	1.1803
4622	4623	$307x$ 1.3032	1.3028
4592	4593	$309x$ 1.3117	1.3113

The thallium line, 5340, is the only one which differs enough from the harmonic length to throw doubt on its subjection to harmonic influence. If this line were omitted altogether in the calculation, the only change would be in the fourth harmonic divisor, which would be 1.0824 instead of 1.0825. The harmonic wave-lengths would all remain the same as above given.

110. *Mechanical Analogies.*

The researches of Challis and Norton have shown how extensively the various operations of energy may be represented and anticipated by applying the laws of fluid motion. My own kinetic investigations have been greatly helped by my apparatus,* for imitating the "lines of force" which are represented by atmospheric, thermal and electric currents. The telephone, phonograph and photophone furnish practical illustrations of the "mechanical polarization" for which my apparatus was devised. M. C. A. Bjerknes has lately sent a communication to the French Academy "*sur l'imitation, par la voie hydrodynamique, des actions électriques et magnetiques.*" As the indications of unity of force increase, there will be an increased call for the study of such analogies with the help of mechanical contrivances.

111. *Subsident and Parametral Nodes.*

If we take Sun's semi-diameter, Laplace's limit and Earth's nascent locus† as the elements of the stellar-solar paraboloid, we find

$$\eta^2 = 2\,p\,\xi = .9958534$$
$$\xi = .1666667$$
$$2\,p = 5.950342$$

The product of the parameter by any paraboloidal abscissa represents the corresponding ordinal *vis viva*, and the laws of harmonic undulation in elastic media lead us to look for nodes in accordance with the living force. We find numerous evidences of such accordance in the primitive cometoid nebula, if we suppose the nucleal tendencies in the axis of abscissas to be

* For description see Proc. Amer. Phil. Soc., x, 151-66.

† Note 46, *ante*, xix, 446.

arranged in the following order; Neptune (N), Jupiter (J), Mars (M), Sun (S), Mercury (Me), Venus (V), Earth (E), Saturn (Sa) Uranus (U). Let subscript 1, 2, 3, 4, 5 designate, respectively, secular perihelion, mean perihelion, mean, mean aphelion, secular aphelion. Then

1. Subsidence from N_3 would produce a rupturing node at U_4.* Stockwell's values are, $N_3 = 30.034$, $U_4 = 20.044$, the rupturing locus being $\frac{2}{3}$ of $30.034 = 20.023$. Newcomb's estimate of N_3 is 30.070, which would give 20.047 for the rupturing locus.

2. Midway between these primitive nodes comes the primitive nebular centre, J_2. Three of Jupiter's cardinal loci are thus approximately indicated, viz.:

$$(N_3 - U_4) \div 2 = 4.995\ ;\ J_2 = 4.978$$
$$(N_5 - U_4) \div 2 = 5.213\ ;\ J_3 = 5.203$$
$$(N_5 - U_3) \div 2 = 5.425\ ;\ J_4 = 5.427.$$

3. The rupturing locus of the early nebular centre, J_1, and the locus of incipient subsidence at the centre of the belt of greatest condensation, E_5, present the most significant evidence of parametral influence.

$$J_1 + E_5 = 5.954\ ;\ 2p\ E_5 = 5.950$$

4. Other important loci in the dense belt show a like influence.

$$J_4 + V_4 = 5.952$$
$$J_5 + Me_4 = 5.975$$

5. The influence of the parameter on other fundamental abscissas is equally evident.

$$2p\ Me_1 = 1.770\ ;\ M_5 = 1.736$$
$$2p\ M_3 = 9.066\ ;\ Sa_2 = 9.078$$
$$2p\ M_5 = 10.333\ ;\ Sa_5 = 10.343$$
$$2p\ J_2 = 29.622\ ;\ N_1 = 29.598$$
$$2p\ Sa_4 = 59.504\ ;\ 2N_2 = 59.465$$

6. Simple ordinal influence is shown in the relations of Laplace's limit (L) to the centre of condensation, and of the three inner to the three outer planets, if we take Sun's semi-diameter (r_0) as the unit of measurement.

$$\sqrt{2p\ E_4 \div r_0} = 36.322\ ;\ L = 36.366 r_0$$
$$\sqrt{2p\ J_4 \div r_0} = 83.238\ ;\ Me_3 = 83.048 r_0$$
$$\sqrt{2p\ U_3 \div r_0} = 156.491\ ;\ V_3 = 155.184 r_0$$
$$\sqrt{2p\ N_5 \div r_0} = 197.223\ ;\ E_1 = 200.008 r_0$$

7. A similar influence is shown with E_3 as the fundamental abscissa.

$$\sqrt{2p}\ E_3 = 2.439\ ;\ E_4 + M_2 = 2.437$$
$$2\sqrt{2p}\ E_3 = 4.879\ ;\ J_1 = 4.886$$

8. Some of the relative nodes show simple multiples of the parameter.

$$4p = 11.901\ ;\ N_1 - U_1 = 11.910\ ;\ U_5 - Sa_1 = 11.945$$
$$6p = 17.851\ ;\ U_1 = 17.688$$
$$10p = 29.750\ ;\ N_2 = 29.732$$

* Ibid, xvii, 100.

112. *Motion of the Solar System.*

If the interstellar paraboloid (Note 46) were at rest, we should have $\eta = 2\xi$; it is, however, equivalent to 5.975ξ. I can think of no other reason for this increase than the absolute motion of the system in space. If the space traversed in a quarter of a solar rotation (6.377 days) is similarly increased we have

$$\xi : \eta\zeta :: r_0 : y$$
$$\text{or } \tfrac{1}{6} : 1.00877 :: r_0 : 6.05264 r_0$$

This would give, for the space traversed in a year, $\frac{365.256}{6.377} \times 6.05264 r_0$. Dividing by 214.45, we obtain 1.6166 times Earth's semi-axis major. Herschel's estimate of the annual motion* is 1.623 semi-axes.

113. *Relation between Jupiter's Mass and Distance.*

The original tendency to relative stability in the positions of the two principal masses of our system, on account of the magnitude of Sun and the nebular-centrality of Jupiter, appears to have made Sun's surface the rupturing locus (secular-perihelion), of the centre of gravity of the two bodies. Stockwell gives, for Jupiter's maximum eccentricity, .0608274; secular perihelion is, therefore, .9391726 of the semi-axis major. If we accept Bessel's mass, we find $1047.879 \div .9391726 = 1115.75 r_0$. Dividing by 5.202798, we find, for Earth's semi-axis major, $214.45 r_0$, which is the value adopted in the British Nautical Almanac.

114. *The Central Sun.*

The true culminating abscissa of the stellar-solar paraboloid (Note 46), is $A_{28} = LM \div r_0$. There is a very large *possible* uncertainty in the distance of *a Centauri*, and even if we take the most recent and careful estimates we may set down the probable error as at least $\pm .04$. Moreover, as the theoretical variability of the abscissas is principally due to variability of æthereal density, A_{29} may represent any point in the orbit of *a Centauri* about the centre of its stellar system. The mean R. A. of *a Centauri* is about 217°53′ and its declination 60°21′S; the opposite pole of the paraboloid, or the theoretical direction of the "Central Sun," if our Sun has been projected from *a Centauri*, should therefore be in the constellation Cassiopeia. The direction of Sun's apparent motion among the fixed stars has been variously estimated between R. A. 252°53′ and 261°22′, and between N. Dec. 38°37′, and 14°26′. Struve's result, from an elaborate discussion of the proper motions of 392 stars, was R. A. 261°22′, Dec. 27°36′, for A. D. 1790. This position is 4°51′ north of the great circle which is at right angles with the axis of the Centaurean paraboloid.

* Outlines of Astronomy, Sect. 853.

115. *The Milky Way and Mädler's Hypothesis.*

Sir John Herschel* objects to Mädler's assignment of "the local centre in space, round which the sun and stars revolve" to the group of the Pleiades, "lying as it does no less than 26° out of the plane of the galactic circle, out of which it is almost inconceivable that any *general* circulation can take place." No such objection can be urged against the radius-vector of the Centaurean paraboloid, for the Milky Way divides at *α Centauri*,* and it traverses Cassiopeia, "its brightest part passing about two degrees to the north of the star δ of that constellation."*

116. *Daily Variations of the Magnetic Needle.*

Sabine's discussions of the magnetic observations at various stations have shown :

1. That the diurnal variation of declination which is due to the Moon's action consists of four equal or nearly equal portions, in which the magnet is attracted alternately to the east and to the west of its mean position.

2. That there is a striking correspondence between the lunar-daily variations of horizontal force and of declination.

3. That in the normal variations of vertical force, the lunar day is also divided into four alternating periods of nearly equal duration, in two of which the force is increased and in the other two it is diminished by the lunar influence.

4. That the lunar-daily variations of inclination and of total force also constitute double progressions, having two maxima and two minima, with alternate periods of increase and decrease, each period being of about six hours' duration.

5. That the solar-daily variations normally constitute only single progressions, of about twelve hours each, from maximum to minimum and from minimum to maximum.

6. That there are, however, "nocturnal episodes" of "retrogressive motion" at some stations, with tendencies to a triple instead of double division of the solar day.

I have shown, by experiment :

7. That any elongated body, when exposed to the action of parallel rectilinear undulations, tends to place itself in the line of those undulations.

8. That this tendency may be increased by giving the elongated body a slight specific energy of direction. For example: if the gimbals of a binnacle compass are so held as to allow motion only in one direction, and the box is made to swing on its free axis like a pendulum, the needle will tend towards the line of oscillation.

The single progression of the solar disturbances (5) and the double progression of the lunar disturbances (1—4) indicate a difference in the character of the chief disturbing influences of the two bodies. It is difficult to

* Op. cit. Sect., 861, 789, 787.

account for such difference by any theory of magnetic induction.* It is evident, however, that Sun's thermal disturbance of Earth's æthereal currents is greater than Moon's, while Moon's tidal disturbance of the same currents is greater than Sun's.

117. *Magnetic Variations at St. Helena.*

St. Helena, on account of its insular position, its proximity to the magnetic equator, its large horizontal force and the large proportion of total force which is represented by the horizontal force, is free from many of the local complications which often mask the normal action of the Sun and Moon. Moreover, the comparatively long period of systematic observations, the extension of the observations to the lunar action on the barometer as well as on the magnetic needle, the uniformity of the indications in different years and in different semesters, and the symmetry which is traceable between the lunar atmospheric and magnetic disturbances, are additional reasons for regarding it as a typical station for the study of gravitating influence on æthereal waves.

118. *Comparative Table.*

The difference between the solar and lunar disturbances is shown in the following synoptical table. The magnetic data are taken from the second volume of the St. Helena Observations, pp. xlii-xliv and lviii-lxii; the barometric, from the first volume, pp. 84, 99. The barometric *ratios* are given, in order to make the table homogeneous and facilitate comparison. They were obtained by dividing the hourly deviations from the mean by the mean height of the barometer (28.278 in.).

SOLAR DISTURBANCES.

☌	Bar.	V. F.	H. F.	T. F.
☉	.00	.000	.00	.000
0	+0566	—022	+1099	+95
1	—0035	+229	+0911	+82
2	—0530	+446	+0623	+60
3	—0954	+593	+0368	+40
4	—1061	+638	+0133	+20
5	—0920	+608	—0080	+01
6	—0636	+611	—0270	—15
7	—0212	+545	—0394	—26
8	+0247	+300	—0465	—36
9	+0636	+219	—0511	—41
10	+0848	+074	—0530	—45
11	+0742	—011	—0522	—45
12	+0354	—100	—0481	—43
13	—0106	—165	—0449	—41

*See paper by Dr. Lloyd, Proc. R. Irish Acad., 1858, and C. Chambers, Phil. Trans., 1863.

SOLAR DISTURBANCES.

☉	Bar.	V. F.	H. F.	T. F.
14	—0566	—224	—0405	—38
15	—0884	—289	—0376	—36
16	—0919	—345	—0352	—35
17	—0742	—398	—0329	—34
18	—0247	—465	—0298	—32
19	+0318	—513	—0154	—20
20	+0813	—582	+0130	+03
21	+1202	—491	+0470	+34
22	+1308	—425	+0803	+63
23	+1061	—214	+1019	+85

LUNAR DISTURBANCES.

☽	Bar.	V. F.	H. F.	T. F.
☊	.000	.0000	.0000	.0000
0	+619	—05	+06	+05
1	+523	+27	—03	—01
2	+300	+31	—11	—05
3	—035	+44	—14	—06
4	—318	+72	—20	—07
5	—477	+41	—14	—06
6	—749	+50	—07	+01
7	—619	+28	—04	+01
8	—290	—12	00	—02
9	+007	—11	+22	+18
10	+205	—17	+32	+25
11	+488	—37	+31	+22
12	+566	—03	+19	+16
13	+417	+05	+17	+15
14	+194	+19	+13	+14
15	—255	+48	—09	—01
16	—417	+51	—11	—02
17	—530	+29	—08	—03
18	—644	+13	—09	—06
19	—513	—11	—04	—05
20	—290	—53	+03	—05
21	—265	—50	+06	—02
22	+407	—54	+13	+04
23	+548	—67	+09	—01

119. *Magnetic Correlations.*

In studying the above table for a proper interpretation of its indications, we can follow no better clew than the known correlations of electricity and magnetism, which may be classed under the following heads:

a. Friction.—Thermal and tidal currents, combined with the resistance of the Earth's surface, must produce atmospheric friction.

β. *Chemical Action.*—The evidences of incessant dissociation and re-association in the solar photosphere, are so conclusive, that chemical action may be very properly regarded as an important source of specific solar magnetism.

γ. *Light.*—The numerical equivalences between various forms of luminous, gravitating, and electro-magnetic action, are so striking as to justify Maxwell in the assertion that "the properties of the electro-magnetic medium are identical with those of the luminiferous medium."*

δ. *Heat.*—Edlund has shown that many of the phenomena of heat and electricity may be explained by the hypothesis of two forms of motion in the same elastic æthereal medium.

ε. *Rotation.*—Arago, Babbage, Herschel, Barlow, Christie, Chase, and Perry and Ayrton, have shown that simple rotation produces magnetical disturbances which are governed by fixed laws.

ζ. *Gravitation.*—In addition to the relation which I have shown to exist between solar rotation and luminous velocity, it is evident that electricity must be modified by pressure and by such changes in the relative distances of electrified particles as are produced by disturbances of gravitating equilibrium.

η. *Currents.*—A comparison of oceanic currents with the cotidal lines, the lines of isabnormal temperature and the magnetic lines of equal declination, shows such points of resemblance as to make it probable that they are all due to the action of the same forces upon different media, or under different circumstances. Challis has found that if all the ordinary central forces are due to transformed æthereal vibrations, "the actions of such forces on atoms are in every instance attributable to *æthereal currents*, whether the atoms be *immediately* acted upon by steady motions of the æther or by æthereal vibrations." †

120. *Comparison of Solar Daily Magnetic and Meteorological Means.*

The solar-daily maximum of vertical force at St. Helena is coincident with the daily barometric minimum, as well as with the minimum of gaseous pressure and of mean pressure of the wind. The daily minimum of vertical force (20 h) is approximately coincident with the daily maximum of the barometer (22 h), of gaseous pressure (21 h), and of wind pressure (22–23 h). The most rapid increase of vertical force is between 22 h and 3 h, when the barometer is falling and the gaseous pressure diminishing; the most rapid diminution is between 7 h and 10 h, when the barometer is rising and the gaseous pressure increasing. The range of total force between noon and midnight ($.00095 + .00043 = .00138$), is of the same order of magnitude as the daily range of solar disturbances of weight or pressure $\left(\frac{m}{d^2_s} = .000615\right.$, which is added at midnight and subtracted at

* *Electricity and Magnetism*, II, 383, sqq.
† *Phil. Mag.*, Sept. 1872; Sept. 1876; June, 1878.

noon, making the total range .00123). The arithmetical mean of any cumulative disturbances which are occasioned by the accelerations and retardations of alternate half-daily fall towards and rise from the Sun, should occur at 12h $\pm \sqrt{2}$ from midnight, or at 8h. 29m. A.M. and 3h. 31m. P.M. These hours correspond very nearly with those of mean disturbance, both in the horizontal and in the total force:

	Noon.	12 P.M.	Mean.	Time of Mean.
H. F.	+.001099	—.000481	+.000309	8h. 31m. A.M.; 3h. 16m. P.M.
T. F.	+.00095	—.00043	+.00026	8h. 45m. A.M.; 3h. 42m. P.M.

The greatest observed deviation from the theoretical times is 16m, in the morning mean of total force; the least, 2m., in the morning mean of horizontal force. The mean deviation of horizontal force is 8.5m.; of total force, 2.5m.

121. *Lunar Daily Comparison.*

The lunar disturbances, both of the barometric and of the magnetic means, are of a higher order than can be accounted for by mere disturbances of weight or pressure, or by any other known activity of our satellite except the accumulation of energy in currents (η). We have no reason to think that the moon exerts any specific chemical (β), luminous (γ), or thermal (δ) influence of her own, but her tidal disturbances of the elastic or *quasi*-elastic currents of the rotating earth (ε,ζ,η) are very important.

Schiapparelli, Loomis and Chase have shown that long-continued observations, at various stations, demonstrate the existence of an evident lunar influence on the precipitation of rain, and, consequently, on the electrical condition of the atmosphere. Each station has an "establishment" of its own, which can be determined, where the meteorological conditions are most uniform, by observations extending over a period of three or four years. This influence, which is undoubtedly due to tidal disturbances of atmospheric currents, is further shown in the lunar modifications of the direction and velocity of the wind, which have been pointed out by M. Bouquet de la Grye.*

Both in the lunar and in the solar tables the critical periods of horizontal and total force are nearly synchronous. In the lunar variations the vertical force increases as the horizontal force diminishes, and *vice-versâ*. Each of the lunar magnetic tides is of the same general character as the oceanic and atmospheric tides. The lunar horizontal force and total force are greatest and the vertical force is least when the barometric currents are moving most rapidly away from the Earth's centre; the horizontal and total force are least and the vertical force is greatest when the currents are moving most rapidly towards the centre.

The range of lunar disturbances of vertical force (from + .000072 to

* *Comptes Rendus*, lxxxviii, 345-8.

— .000067 = .000139) is almost identical with the range of lunar barometric disturbances (from — .000075 to + .000062 = .000137).

The culminations of the lunar disturbances, both of the vertical and of the horizontal force, correspond approximately with the mean sum of the accelerations and retardations of lunar tidal action by terrestrial rotation (6h ÷ $\sqrt{2}$ = 4h 14.6m after 0h, 6h, 12h, 18h.)

Vertical Force.		Horizontal Force.	
1st Max.	0h + 3h 57m	1st Min.	0h. + 4h 1.3m
1st Min.	6h + 4h 51.5m	1st Max.	6h. + 4h 24.4m
2d Max.	12h + 3h 36.1m	2d Min.	12h. + 3h 44m
2d Min.	18h + 4h 39.8m	2d Max.	18h. + 4h 9.2m
Mean	4h 16.1m	Mean	4h 4.7m

122. *Conclusions.*

Although the barometric observations furnish the most ready data for quantitative measurements and comparisons, the combined action of terrestrial rotation with lunar tidal and terrestrial equilibrating gravitation is not confined to the air. Every particle of the globe is continually subject to cyclical variations of stress and strain. In the first and third quadrants the lunar action is opposed, while in the second and fourth it is aided, by terrestrial rotation, so that the resultant of all the subterranean magnetic influences must be subject to lunar disturbances of the same character as those which modify the barometric and electric currents in the atmosphere.

We may, therefore, conclude that the solar disturbance of the terrestrial magnetic currents is chiefly and primarily due to its thermal activity; the lunar, to gravitating currents which are modified by terrestrial rotation and orbital revolution.

123. *"Forced Oscillation."*

In discussing the synchronism of the motion of the moon's nodes with terrestrial nutation Herschel* introduces "the principle of forced oscillations, or of forced vibrations," by the following announcement:

"If one part of any system connected either by material ties, or by the mutual attractions of its members, be continually maintained by any cause, whether inherent in the constitution of the system or external to it, in a state of regular periodic motion, that motion will be propagated throughout the whole system, and will give rise, in every member of it and in every part of each member, to periodic movements executed in equal period with that to which they owe their origin, though not necessarily synchronous with them in their maxima and minima."

A demonstration of this theorem for the forced vibrations of systems connected by material ties of imperfect elasticity, is given in Herschel's Treatise on Sound.† Fourier's theorem, Herschel's theory of the consequences of

* *Op. cit.*, Sect. 650.

† Encyc. Metrop., Art. 323.

nebular subsidence, and the various forms of harmonic synchronism are all dependent upon the same fundamental principles and they should all be kept in mind by those who are investigating the consequences of elastic action and reaction.

124. *Fundamental Photodynamic Nodes.*

The principle of forced vibrations, the theory of subsidence, and the laws of varying density in elastic media, are illustrated by the equation,

$$\left(\frac{L}{r}\right)^{\frac{L}{r}} = \left(\frac{M}{r}\right)^{\frac{i}{c}}$$

$$\therefore \log. L : \log. M :: \frac{i}{c} : \frac{L}{r}$$

$L =$ Laplace's limit of synchronous solar rotation and revolution ; $M =$ modulus of light at Sun's surface ; $r =$ Sun's semi-diameter ; $i =$ locus of mean incipient subsidence for the nebular centre of planetary inertia, (Saturn's mean aphelion); $c =$ central locus of greatest belt-condensation (Earth's semi-axis major).

If we adopt the values for L and M which are given in Note 46, we find $i = 9.99861\,c$. Stockwell's value is about $\frac{1}{76}$ of one per cent. greater, or $10.000059\,c$.

125. *A "Derivative Oscillation."*

After announcing the principle of forced vibrations, Herschel continues as follows : "The system may be favorably or unfavorably constituted for such a transfer of periodic movements, or favorably in some of its parts and unfavorably in others ; and accordingly as it is the one or the other, the *derivative* oscillation (as it may be termed) will be imperceptible in one case, of appreciable magnitude in another, and even more perceptible in its visible effects than the original cause in a third ; of this kind we have an instance in the Moon's acceleration."

A harmonic illustration of this statement is furnished by the lunar disturbance of vertical magnetic force at St. Helena. Von Littrow's estimate of Moon's semi-axis major is 60.2778. Earth's action upon Moon and Moon's reaction should therefore be nearly $\frac{1}{3633}$ as great as its action at its own surface. If the resulting waves or "forced vibrations" are reflected to Earth and resolved, one-half into vertical force and one-half into horizontal force, the consequent disturbance should be $\frac{1}{7267}$. The lunar disturbance of vertical force (Note 121) is $\frac{1}{7194}$; of barometer, $\frac{1}{7299}$. The decimal values are :

Disturbance of vertical force	.0000139
" " vibrations	.0000138
" " barometer	.0000137

The derivative oscillation in the horizontal force is obscured by other disturbances.

126. *Relation of Magnetic Disturbances to Thermal Currents.*

The secondary character of the solar disturbances of vertical force at St. Helena is further indicated by a comparison of culminating times. The coincidence of the daily minimum of vertical force with the various maxima of gravitating pressures (Note 120) is only approximate; but the relation both of maximum and of minimum to the culmination of ascending and descending currents is very close. The mean time of maximum temperature is 1 h 39.5 m; of minimum temperature, 17 h 41.6 m; of greatest vertical force, 4 h 4.4 m; of least vertical force, 19 h 55.8 m. Therefore, the vertical force continues to increase for 2 h 24.9 m after the time of greatest daily heat, and to diminish for 2 h 14.2 m after the time of greatest daily cold.

127. *Relation of Barometric to Gravitating Disturbances.*

During the forced vibrations of half-daily terrestrial rotation towards and from the Sun, terrestrial gravity acts on all the heated and otherwise disturbed particles of the atmosphere. The sum of the cyclical accelerations, at St. Helena, is $\frac{16.05 \times 43082^2}{5280} = 5642000$ miles $= a$. The sum of the synchronous "forced oscillations" of rotation towards or from the Sun is cos. $15^\circ\,56'\,41'' \times \pi \times 3962.8 = 11970.7$ miles $= \beta$. The mean sum of the barometric pressures of the atmospheric particles is 28.278 inches $= \gamma$. The sum of the mean half-daily disturbances of pressure is $\frac{1}{2}(28.315 - 28.248 + 28.302 - 28.252) = .0585$ inch $= \delta$. The ratio of a to β is nearly the same as that of γ to δ; $\frac{\beta}{a} = .002122$; $\frac{\delta}{\gamma} = .002069$; the deviation from exact accordance being about 2.56 per cent.

128. *Succession of Forced Oscillations.*

The "nascent" velocity of the Sun, or the limiting velocity between complete dissociation and incipient aggregation, is, as we have seen, $\frac{g_o t_o}{2}$ = velocity of light. On the principle of forced oscillations, the luminiferous æthereal undulations force the sun into rotary oscillations synchronous with the cycles of superficial gravitating activity which would communicate the velocity of light.

The ratio of the mass aggregation at the principal centre of nucleation (Sun), to the mass aggregation at primitive nebular centre (Jupiter), is, as we have seen, the same as the ratio of the rupturing radius-vector of Jupiter to the rupturing radius-vector of Sun. The rupturing energy of the æthereal oscillations is thus traceable to the primitive condition of statical equilibrium, when the two products of mass by rupturing radius were equal.

These two principal masses of the solar system tend to produce a system

of forced oscillations through their common centre of gravity. Circular orbital velocity at their mean centre of gravity has become "nascent" velocity for the mass at the centre of the belt of greatest condensation (Earth).

129. *Radius of Primitive Condensation.*

The importance of the three masses, which were considered in the foregoing note, seems to strengthen the probability that the resulting oscillations are *exactly* recorded in relations of mass, distance and velocity. If such is the case, Earth's semi-axis major may be easily computed.

1. Earth's nascent velocity is $\frac{g_3 t_3}{2} = \frac{32.087 \times 43082}{5280} = 261.81$ miles.

2. The mean locus of the centre of gravity of Sun and Jupiter is $\frac{5.2028}{1047.879 + 1}$ of Earth's semi-axis major.

3. If $\sqrt{g_\circ r_\circ} = 261.81$, Earth's orbital velocity is $\left(\frac{5.2028}{1047.879 + 1}\right)^{\frac{1}{2}} \times 261.81 = 18.4392$ miles per second.

4. This would give, for Earth's semi-axis major, 18.4392×1 year in seconds $\div 2\pi = 92{,}613{,}000$ miles.

130. *Paraboloidal Inclination.*

The progression of the stellar-paraboloidal abscissas may be expressed under the form $\xi(\eta\zeta^n)^n$, positive values of n giving centripetal, and negative values giving centrifugal abscissas. The η ordinates are, therefore, modified by ζ, as often as the fundamental abscissa is modified by the *modified* ordinate. The ζ modification seems to imply a cyclical elliptic-influence consequent upon rotation. If ζ is the semi-axis major and η the semi-axis minor of the ellipse, the inclination of the ellipse to the η circle may be readily found by the equation

$$\text{Sec. } \varphi = \frac{\zeta}{\eta} = \frac{1.012974}{.9958534}$$

$$\varphi = 10^\circ\ 32'\ 56''.$$

131. *Other Cometary Hypotheses.*

The hypothesis in Note 114 is only one out of many which might be assumed with nearly equal probability. The great FACT which is to be accounted for is the evidence of paraboloidal influence, extending from the region of the nearest fixed stars to our Sun, and affecting intra-nucleal nodal condensations, revolutions and rotations, through cyclical undulations which are harmonically determined by the inertia of Sun's mass and the velocity of light. I have already shown some of the important modifications which are introduced into the nebular hypothesis by these evidences of paraboloidal or cometoid subsidence, and I look confidently for the discov-

ery of many others. The connection of comets with meteoric streams will, doubtless, awaken many inquiries respecting stellar groups and stellar motions, some of which may be within the reach and others beyond the reach of future satisfactory solution.

132. *Further Paraboloidal Harmony.*

Let r_a be a fourth proportional to Jupiter's locus of incipient subsidence,* Earth's semi-axis major and Sun's semi-diameter. Then the first three abscissas of Note 46 ($A_0 - A_3$) determine the paraboloid, and there are four groups of 3^2 abscissas, between r_a and the fixed stars, viz.: 9, ($A_3 - A_{11}$), between r_a and Sun's semi-diameter; 9, ($A_{12} - A_{20}$), between Sun's surface and the loci of planetary rupture; 9, ($A_{21} - A_{29}$), within the belt of rupturing loci; 9, ($A_{30} - A_{38}$), between the rupturing loci and α *Centauri*. The influence near the centre of the belt of greatest condensation appears to be also traceable in the ratio between the rupturing abscissas for Earth and Venus, $A_{23} \div A_{22} = 1.77875$,

$$\begin{aligned}
\log.\ 1.77875^{-3} &= -.7503432 \\
\log.\ 1.77875^{0} &= \ .0000000 \\
\log.\ 1.77875^{6} &= \ 1.5006864 \\
\log.\ 1.77875^{16} &= \ 4.0018304 \\
\log.\ 1.77875^{30} &= \ 7.5034320
\end{aligned}$$

By referring to the table in Note 46, it will be seen that the division of the abscissas into four groups of nine each is indicated by these logarithms. It may be well also to observe that 1.77875^4 differs by less than $\frac{1}{10}$ of one per cent. from Stockwell's value for Saturn's mean aphelion, estimated in terms of Earth's semi-axis major.

133. *Another Confirmation of Prediction.*

On the 4th of October, 1878, I presented a communication to the American Philosophical Society,† in which I showed that the position of Watson's first intra-Mercurial planet, as computed by Gaillot and Mouchez, represented the third intra-Mercurial term of my harmonic series. At the last meeting of the British Association, Prof. Balfour Stewart read a paper in which he gave indications of sun-spot disturbances by a planet, revolving in 24.011 days, and consequently having a semi-axis major of .163. This confirmation, both of my own prediction‡ and of the calculations of the French astronomers, is the more interesting, because the first confirmation of my series was contained in a communication which was made to the Royal Society by Messrs. De la Rue, Stewart and Loewy, forty-one days

*Secular aphelion.
†Proc. Am. Phil. Soc., xviii, 34-6.
‡*Ib.* xiii, 238.

after I had announced the series to the Philosophical Society and published it in the New York Tribune.* The accordances are as follows:

Prediction.		Confirmation.	
1st interior harmonic term....	.267	De La Rue, S. and L.....	.267
3d " " "	.165	Gaillot and Mouchez.....	.164
		Stewart.....	.163

134. *Prout's Hypothesis.*

Clarke (P. Mag. [5] xii, 109-10), gives the results of his re-calculation of atomic weights, which inclines him to look favorably on Prout's hypothesis, although he had previously believed that it had been forever overthrown. Maximilian Gerber (Les Mondes; cited in Chemical News, xliii, 242-3), rejects the hypothesis, but he gives four additional empirical units, which seem to indicate a probability that groups of similar valency may have special common divisors. The varied evidences of the photodynamic importance of hydrogen will doubtless incline chemists to give weighty consideration to Clarke's deliberate opinion, and Gerber's factors may help towards its establishment. The possibility of measuring undulatory *vis viva* by the distance of projection against uniform resistance, as well as by orbital areas, may, perhaps, furnish the requisite clue for reconciling apparent oppositions of indication.

135. *Phyllotactic Atomicity.*

The phyllotactic law distributes leaves and branches evenly around the stems of vegetables, so that all parts of the plant may share in the benefit of heat, air and moisture. In 1849, Dr. Thomas Hill, at the request of Prof. Peirce, showed that the times of planetary revolution are phyllotactic, and the planets are thus distributed around the Sun so evenly as to avoid the destruction of the system by the accumulated perturbations of the great planets.† If the several atomic elements have special systems of æthereal vibrations, it seems reasonable to look for evidences of a phyllotactic harmony which would contribute to the stability of equilibrium in compounds. The following table, which includes about half the known elements, contains multiples of the phyllotactic divisor $\frac{8}{5}$ H, or 1.6 H, compared with Clarke's recalculation of atomic weights.

	Phyllotactic.		Clarke.	Difference.
O	$10 \times 1.6 =$	16	15.963	.037
Fl	$12 \times 1.6 =$	19.2	18.984	.216
Mg	$15 \times 1.6 =$	24	23.951	.049
S	$20 \times 1.6 =$	32	31.984	.016
Cl	$22 \times 1.6 =$	35.2	35.370	.170
Ca	$25 \times 1.6 =$	40	39.990	.010
Ti	$31 \times 1.6 =$	49.6	49.846	.246

* *Ib.* p. 470.

† Proc. Amer. Assoc., vol. 2.

	Phyllotactic.	Clarke.	Difference.
V	$32 \times 1.6 = 51.2$	51.256	.056
Se	$49 \times 1.6 = 78.4$	78.797	.397
Br	$50 \times 1.6 = 80$	79.768	.032
Zr	$56 \times 1.6 = 89.6$	89.367	.233
I	$79 \times 1.6 = 126.4$	126.557	.157
Te	$80 \times 1.6 = 128$	127.960	.040
Cs	$83 \times 1.6 = 132.8$	132.583	.217
Ytter	$108 \times 1.6 = 172.8$	172.761	.039
Bo	$7 \times 1.6 = 11.2$	10.940	.260
Al	$17 \times 1.6 = 27.2$	27.009	.191
Fe	$35 \times 1.6 = 56$	55.913	.087
Ga	$43 \times 1.6 = 68.8$	68.854	.054
Cd	$70 \times 1.6 = 112$	111.770	.230
In	$71 \times 1.6 = 113.6$	113.398	.202
Yt	$56 \times 1.6 = 89.6$	89.816	.216
Ru	$65 \times 1.6 = 104$	104.217	.217
Ro	$65 \times 1.6 = 104$	104.055	.055
Rh	$66 \times 1.6 = 105.6$	105.737	.137
Sb	$75 \times 1.6 = 120$	119.955	.045
Ta	$114 \times 1.6 = 182.4$	182.144	.256
W	$115 \times 1.6 = 184$	183.610	.390
Os	$124 \times 1.6 = 198.4$	198.494	.094
Hg	$125 \times 1.6 = 200$	199.712	.288
Pb	$129 \times 1.6 = 206.4$	206.471	.071
Th	$146 \times 1.6 = 233.6$	233.414	.186
U	$149 \times 1.6 = 238.4$	238.482	.082

The greatest difference in the above table of 33 elements is less than 25 per cent. of the phyllotactic unit. Gerber's longest table, for a single divisor, contains but 25 elements; his greatest difference is more than 36 per cent. of his empirical divisor. If the eight elements which present the greatest phyllotactic difference were rejected, so as to make the tables of the same length, the greatest remaining difference would be less than 15 per cent. of the divisor. The photodynamic approximation is therefore much closer than the empirical.

136. *The Empirical Divisors are Phyllotactic.*

Gerber says that "no simple relation exists among" his divisors, therefore they "have no value in themselves." The relation which he was unable to discover, is phyllotactic, as will be seen by the following comparisons:

	Gerber.	Phyllotactic.	
H	.9997	H	.998
D_1	.769	$\frac{5}{13} \times 2$ H	.768
D_2	1.995	2 H	1.996
D_3	1.559	$\frac{4}{5} \times \frac{5}{4}$ H	1.559
D_4	1.245	$\frac{5}{2} \times \frac{1}{2}$ H	1.247

The first six phyllotactic numbers are 1, 2, 3, 5, 8, 13; the third does not appear in the formation of the theoretical divisors, but the others are all employed. The simple phyllotactic relation of all the divisors to H, shows that they *have* "value in themselves."

137. *Mutual Phyllotaxy.*

Upon examining the mutual relations of the above phyllotactic divisors, it will be seen that $D_1 = \frac{5}{13} D_2 = 2 \times \frac{3}{5} \times \frac{5}{13} D_3 = \frac{5}{13} D_4$; $D_2 = 2 \times \frac{3}{5} \times \frac{3}{5} D_3 = 2^2 \times \frac{3}{5} D_4$; $D_3 = \frac{1}{2} \times \frac{1}{2} D_4$; $D_4 = \sqrt{H D_3}$. These varied provisions for the stability of cyclical equilibrium, in all possible varieties of intra-molecular æthereal movement, show that the command, "Let there be light," manifested its formative power of organization as soon as material atoms were set in motion. The appearance of the first five phyllotactic numbers, 1, 2, 3, 5, 8, in crystallization, furnishes a step from inorganic to organic morphology, giving new meaning to the landscapes on our frosted window-panes, as well as to the protective mimicry of vegetables and animals, as illustrations of the "distributive ratio" which controls alike light-waves, atomic inertia, crystalline structure, organic growth, planetary configuration and interstellar action.

138. *Relations of the Water Molecules.*

The importance of oxygen and hydrogen, both in mutual combination and in connection with other elements, suggests the following comparative grouping of Clarke's table of atomic weights:

O = 16; H = 1.0023.		Difference.		O = 16; H = 1.0023.	Difference.
Br	79.951	.049	Bi	208.001	.001
I	126.848	.152	Pb	206.946	.054
Mg	24.014	.014	Mn	54.029	.029
Zn	65.054	.054	Fe	56.042	.042
Cs	132.918	.082	Ni	58.062	.062
Ag	107.923	.077	Co	59.023	.023
Tl	204.183	.183	Bo	10.966	.034
Se	78.978	.022	Ga	68.963	.037
Mo	95.747	.253	Ce	140.747	.253
W	184.032	.032	Yttr	90 023	.023
U	239.030	.030	Ytter	173.158	.158
P	31.029	.029	La	138.844	.156
Cd	112.027	.027	Di	144.906	.094
Hg	200.171	.171	Th	233.951	.049
Ba	137.007	.007	Pt	194,867	.133
C	12.001	.001	Ir	193.094	.094
Ti	49.961	.039	Os	198.951	.049
Sn	117.968	.032	Pd	105.981	.019
In	113,659	.341			

	H = 1; O = 15.9633.	Difference.		H = 1; O = 15.9633.	Difference.
Fl	18.984	.016	Zr	89.367	.367
Cl	35.370	.370	N	14.021	.021
Li	7.007	.007	Sb	119.955	.045
Gl	9.085	.085	Ta	182.144	.144
Na	22.998	.002	Sc	43.980	.020
K	39.019	.019	Al	27.009	.009
Rb	85.251	.251	V	51.256	.256
S	31.984	.016	As	74.918	.082
Te	127.960	.040	Cu	63.173	.173
Cr	52.009	.009	Er	165.891	.109
Ca	39.990	.010	Rh	104.055	.055
Sr	87.374	.374	Ru	104.217	.217
Si	28.195	.195	Au	196.155	.155

The above tables seem to show that, if Prout's law is correct, the value of the oxygen atom has been more accurately determined than that of the hydrogen atom. The deviations of Mo, In, Ce, Cl, Rb, Sr, Zr, and V, are so great as to require some explanation, which may, perhaps, be found in phyllotactic or harmonic influence.

139. *Further Evidence of Phyllotaxy.*

Upon further examination of Gerber's tables, I find a still closer agreement with rigidly phyllotactic divisors. Taking the mean of the estimated atomic weights, when two are given, his values should be as follows: $D_1 = 655.28 \div 853 = .7681$; $D_2 = 1440.4 \div 722 = 1.9950$; $D_3 = 646.21 \div 415 = 1.5571$; $D_4 = 2763.05 \div 2218 = 1.2457$; $H = 1.3\ D_1 = 9986$. Clarke's values for the atomicities, when grouped in the same way as Gerber's, give $D_1 = 656.212 \div 853 = .7693$; $D_2 = 1437.96 \div 721 = 1.9944$; $D_3 = 643.53 \div 413 = 1.5582$; $D_4 = 2752.051 \div 2208 = 1.2464$; $H = 1.3\ D_1 = 1.0001$. The following table shows the nearness of agreement between the empirical and the phyllotactic divisors:

	Phyllotactic.	Gerber.	Clarke.
$H = \frac{1}{16} O$	.9977	.9986	1.0001
$D_1 = \frac{10}{13} H$	.7675	.7681	.7693
$D_2 = 2\ H$	1.9954	1.9950	1.9944
$D_3 = \frac{8}{5} D_4$	1.5589	1.5571	1.5582
$D_4 = \frac{8}{5} D_2$	1.2471	1.2457	1.2464

140. "*Elasticity.*"

"Sir W. Thomson is led from the consideration of various experiments with fluids and solids and the study of smoke rings to speculate upon elasticity as an evidence of motion. The kinetic theory of gases requires that the molecule or atom shall be elastic. 'But this kinetic theory of matter is a dream and must remain so until it can explain chemical affinity, electricity, magnetism, gravitation and inertia.' The writer looks

forward to a greater generalization which shall include elasticity as a form of motion."—J. T., in *Am. Jour. of Science*, Nov. 1881.

My first physical paper (Proc. Am. Phil. Soc., ix, 283-8), deduced approximate values of solar mass and distance from the combined action of daily rotation, yearly revolution and atmospheric elasticity. All my subsequent radiodynamic investigations have been based upon the consideration of the various forms of harmonic relation which *ought* to follow from the undulations of an all-pervading elastic medium, such as the luminiferous æther is generally supposed to be.

141. *Harmonic Spectra.*

Schuster (*Proc. Roy. Soc.*, xxxi, 337-47), discusses the probability of accidental harmonic coincidences in spectral wave-lengths, giving the following summary of his results for the iron spectrum :—

"1. *There is a real cause acting in a direction opposed to the law of harmonic ratios, so far as fractions formed by numbers smaller than seventy are concerned.*

"2. *After elimination of the first cause a tendency appears for fractions formed by two lines to cluster round harmonic ratios.*

"3. *Most probably some law hitherto undiscovered exists, which in special cases resolves itself into the law of harmonic ratios.*"

The comparison between the planetary harmonic roots and the spectral harmonic quotients (Note 37), suggests the probability that the opposition to strict harmonic ratios may be due to differences of inertia in the wave-systems, which would be more rigidly harmonic were it not for such differences. The simple tendency of all elastic media to harmonic vibrations would then be the general law, instead of a law which becomes harmonic "in special cases."

In waves which are propagated with such rapidity as those of light, it seems reasonable that there may be large factors of harmonic length, which are modified by smaller disturbing elements. Schuster's analysis does not reach such cases as are given in Notes 36, and 39–42. Note 36 gives 11 harmonic divisors, which deviate from the observed divisors by a mean amount of less than $\frac{1}{10}$ of one per cent. The greatest difference is in the C line, where the harmonic divisor is 1.1530, the observed divisor being 1.1592, giving a deviation of $\frac{5}{8}\frac{1}{3}$ of one per cent. In Note 39, the greatest difference between either of the harmonic lines and the corresponding basic line is $\frac{1}{3}$ of one per cent. In Note 41 the greatest difference is $\frac{1}{20}$ of one per cent. In Note 42, $\frac{1}{14}$ of one per cent.

142. *The Magnesium Spectra.*

Liveing and Dewar (Proc. Roy. Soc., xxxii, 189–203), give some results of their investigations on the spectrum of magnesium, which seem to strengthen the probability of large harmonic factors, modified by small disturbances. The only two single lines which are found in the flame-spectrum, the arc-spectrum and the spark-spectrum, have wave-lengths

of 2850 and 4570, respectively. These represent, approximately, the phyllotactic numbers 5 and 8, viz.:

Phyllotactic.	Observed.
2854	2850
4566	4570

In the arc-spectrum and spark-spectrum, there is "a very striking group of two very strong lines at wave-lengths about 2801 and 2794," and "one line common to the arc and spark at wave-length 4703" which "does not appear in Angstrom's table." The difference between the "two very strong lines" has modified the other lines, as shown below :—

Harmonic.	Observed.
$7 \times 399 = 2793$	2794
$7 \times 400 = 2800$	2801
$7 \times 407 = 2849$	2850
$7 \times 653 = 4571$	4570
$7 \times 672 = 4704$	4703

The greatest difference is $\frac{1}{7}$ and the mean difference is $\frac{1}{35}$ of the harmonic divisor. If there were no law controlling the approximations, the probable maximum difference would be $\frac{1}{4}$ and the mean difference would be .25 of the divisor.

143. *The Special Phyllotactic Elements.*

The elements which cannot be simply grouped with O and H, within the limits of probable error (Note 138), have the following phyllotactic relations to oxygen,

	Observed.	Phyllotactic.		Difference.
Mo	$95.747 \times \frac{1}{16}$ O	$2^5 \times 3$	$= 96.$	.253
In	$113.659 \times \frac{1}{16}$ O	$7 \times 13 \times \frac{4}{7}$	$= 113.75$	.091
Ce	$140.747 \times \frac{1}{16}$ O	$3 \times 61 \times \frac{12}{11}$	$= 140.769$	.022
Cl	$35.451 \times \frac{1}{16}$ O	$2 \times 23 \times \frac{12}{11}$	$= 35.385$	.066
Rb	$85.529 \times \frac{1}{16}$ O	$3 \times 37 \times \frac{12}{11}$	$= 85.385$	.144
Sr	$87.575 \times \frac{1}{16}$ O	$5^2 \times 7 \times \frac{1}{2}$	$= 87.5$	.075
Zr	$89.573 \times \frac{1}{16}$ O	$11 \times 13 \times \frac{2}{3}$	$= 89.375$	.198
V	$51.373 \times \frac{1}{16}$ O	$41 \times \frac{1}{4}$	$= 51.25$	.123

144. *Analysis of the Hydrogen Spectrum.*

It seems reasonable to look for clearer evidence of undisturbed or slightly modified harmonic influence in hydrogen, than in any of the heavier elements. Accordingly Professor Johnstone Stoney has "shown that three out of the four lines in the visible part of the spectrum have wave lengths which, to a high degree of accuracy, are in the ratios of 20 : 27 : 32." I find, moreover, that three of the lines are in simple geometric ratio, as will be seen by the following comparison :

Theoretical Harmonic Lines.	Observed.
$\alpha = (2 \times 3)^3 \times 30.379 = 6561.8$	6561.8
$\beta = 5 \times 2^5 \times 30.379 = 4860.6$	4860.6
$\gamma = (\delta^2 \delta)^{\frac{1}{3}} = 4340.1$	4340.
$\delta = 5 \times 3^3 \times 30.379 = 4101.1$	4101.2

The extreme lines are phyllotactic, δ being $\frac{5}{8}$ of α. The greatest discrepancy is $\frac{1}{4\frac{1}{10}}$ of one per cent. which is unquestionably within the limits of probable error.

145. *Application of Schuster's Tests.*

The ratio between the hydrogen lines α and δ is between $\frac{8}{5}$ and $\frac{3}{2}$.

$$\alpha \div \delta = a = 1.59997$$
$$8 \div 5 = b = 1.60000$$
$$3 \div 2 = c = 1.50000$$
$$b - c = d = .10000$$
$$b - a = e = .00003$$

$e \div d = \frac{3}{10000}$, or less than $\frac{1}{33}$ of one per cent. of the probable error.

The ratio between γ and δ is between $\frac{91}{86}$ and $\frac{18}{17}$

$$\gamma \div \delta = a_1 = 1.058227$$
$$18 \div 17 = b_1 = 1.058824$$
$$91 \div 86 = c_1 = 1.058140$$
$$b_1 - c_1 = d_1 = .000684$$
$$a_1 - c_1 = e_1 = .000087$$

$e_1 \div d_1 = \frac{29}{218}$, the probable error being $\pm \frac{57}{218}$.

The ratio between α and β is between $\frac{27}{20}$ and $\frac{77}{57}$.

$$\alpha \div \beta = a_2 = 1.350165$$
$$77 \div 57 = b_2 = 1.350877$$
$$27 \div 20 = c_2 = 1.350000$$
$$b_2 - c_2 = d_2 = .000877$$
$$a_2 - c_2 = e_2 = .000165$$

$e_2 \div d_2 = \frac{165}{877}$, the probable error being $\pm \frac{219}{877}$. If we were to stop here, the test would be pronounced satisfactory, and the evidence of harmonic influences in which all the lines are involved would be conclusive. But if we try another mode of grouping the result will be different.

The ratio between β and δ is between $\frac{32}{27}$ and $\frac{77}{65}$.

$$\beta \div \delta = a_3 = 1.185009$$
$$77 \div 65 = b_3 = 1.184616$$
$$32 \div 27 = c_3 = 1.185185$$
$$c_3 - b_3 = d_3 = .000569$$
$$c_3 - a_3 = e_3 = .000166$$

$e_3 \div d_3 = \frac{166}{569}$, the probable error being only $\pm \frac{143}{569}$. Therefore the test fails in this case.

The ratio between β and γ is between $\frac{28}{25}$ and $\frac{75}{67}$.

$$\beta \div \gamma = a_4 = 1.119816$$
$$28 \div 25 = b_4 = 1.120000$$
$$75 \div 67 = c_4 = 1.119403$$
$$b_4 - c_4 = d_4 = .000597$$
$$b_4 - a_4 = e_4 = .000184$$

$e_4 \div d_4 = \frac{184}{597}$, the probable error being only $\pm \frac{142}{597}$. Therefore the test fails in this case also.

The ratio between α and γ is between $\frac{62}{41}$ and $\frac{65}{43}$.

$$\begin{aligned} \alpha \div \gamma &= a_5 = 1.511936 \\ 62 \div 41 &= b_5 = 1.512195 \\ 65 \div 43 &= c_5 = 1.511628 \\ b_5 - c_5 &= d_5 = .000567 \\ b_5 - a_5 &= e_5 = .000259 \end{aligned}$$

$e_5 \div d_5 = \frac{2}{3}\frac{7}{7}$, the probable error being only $\pm \frac{2}{3}\frac{9}{9}$. The test, therefore, fails again, the number of failures in the whole comparison being equal to the number of confirmations. Hence it is evident that Schuster's criterion is insufficient, at least when the probable errors of observation are not satisfactorily ascertained. Even if the probable errors were known, the proper application of the test would require supplementary calculations of such intricacy as to make it practically inoperative.

146. *Modifications of the Test.*

By increasing the magnitude of the harmonic ratios the test may sometimes be made to indicate a probability. For example, $\beta \div \gamma$ is between $\frac{6}{5}$ and $\frac{7}{6}$. These values give $d_4 = .033333$; $e_4 = .000184$; $e_4 \div d_4 = \frac{1}{3}\frac{1}{5}\frac{4}{3}\frac{4}{3}$, which is less than $\frac{1}{4\,1\,5}$ of the probable error. In like manner $\alpha \div \gamma$ is between $\frac{3}{2}$ and $\frac{4}{3}$. These values give $d_5 = .166667$; $e_5 = .011936$; $e_5 \div d_5 = \frac{1}{1\,5\,6}\frac{1}{2\,1\,5}\frac{9}{5}$, which is less than $\frac{1}{1\,7}$ of the probable error. These results seem to indicate the propriety of harmonic comparisons between terms which are unquestionably of the same order of magnitude. Thus in Schuster's calculation (loc. cit., p. 338), the ratio .96476 lies between $\frac{2}{2}\frac{7}{8}$ and $\frac{2}{2}\frac{8}{9}$, the difference between these two fractions being .016636. The difference of the fraction in the sodium spectrum from the nearest of these comparative fractions is .000152, which is only .00914 of the difference between the fractions themselves, or less than $\frac{1}{1\,0\,9}$ of the probable error.

If a supposed harmonic relation can be represented by a fraction with terms of a single digit, Schuster's test might fail even with the above modification, provided the probable error should be $> \frac{1}{4} \times \frac{1}{5} \times \frac{1}{6}$; if the terms are of two digits, it would not be trustworthy if the probable error was $> \frac{1}{4} \times \frac{1}{1\,3} \times \frac{1}{1\,2}$. If the modifications of *vis viva* in synchronous wave systems are of the same order of magnitude as the variations of planetary eccentricity, the limit of probable error would be at least $\frac{1}{3}$, instead of $\frac{1}{4}$, of the difference between adjacent fractions which have a common numerator. This would be the case for each of the compared pairs of wave lengths, the probability for the entire system being equivalent to the product of all the independent probabilities.

All estimates of abstract probability, in such cases, should be greatly increased by the *a priori* probability, or even the mathematical necessity, that synchronous undulations in elastic media *must be* harmonic. In view of this consideration, the indications of a harmonic tendency pervading an entire system, such as I have pointed out in many of my compari-

sons, are far more significant than any conclusions that can be drawn from more restricted investigations.

Whatever test may be applied, it should always be remembered that the failure to discover a harmonic influence between any two given lines does not affect, in the slightest degree, the evidences of harmonic influence between other lines. The failing cases are entitled to no weight in drawing the final conclusion. We should, therefore, have been justified in stopping our examination of the observed lines in the hydrogen spectrum, as soon as we found that α is harmonically connected with β and δ, and that γ is similarly connected with δ. Even if subsequent discussions had failed to show any probable evidence of harmony between β and γ, β and δ, α and γ, the fact that there are such harmonies operating through the relations of the intermediate to the extreme wave-lengths, would have been unshaken.

147. *Uncertainties of Measurement.*

The influence of probable errors of observation upon the validity of Schuster's criterion may be illustrated by applying it to two of the different values which have been found for the Fraunhofer lines A, B and C. Angstrom's measurements are taken from *Schellen's Spectrum Analysis*, p. 168; Gibbs's, from *Am. Jour. Science*, [2] xliii, 4.

	Gibbs.		Angstrom.
A	761.20		760.09
B	687.49		686.68
C	656.77		656.18
$A \div B = a$	1.107216		1.106906
$b = 31 \div 28$	1.107143	$31 \div 28$	1.107143
$c = 72 \div 65$	1.107692	$83 \div 75$	1.106666
$c - b = d$	.000549	$b - c$	.000477
$a - b = e$	.000073	$b - a$	.000237
$e \div d$	$73 \div 549$		$79 \div 159$
Probable error	$137 \div 549$		$39 \div 159$
$B \div C = a_1$	1.046776		1.046481
$b_1 = 45 \div 43$	1.046512	$45 \div 43$	1.046512
$c_1 = 67 \div 64$	1.046875	$68 \div 65$	1.046154
$c_1 - b_1 = d_1$	.000363		.000358
$c_1 - a_1 = e_1$	.000109	$b_1 - a_1$	.000031
$e_1 \div d_1$	$109 \div 363$		$31 \div 358$
Probable error	$90 \div 363$		$89 \div 358$

Hence the criterion indicates a harmony of vibration, both between the A and B lines, according to Gibbs, and between the B and C lines, according to Schellen. The *a priori* probability or certainty that there must be such a harmony, lends confidence to the greater accuracy of Gibbs's measurement of the A line, and of Schellen's measurement of the C line. If such allowance as I have proposed is made for that probability, the harmony is shown by Gibbs in both comparisons.

148. *The Fraunhofer Harmonies.*

The general accuracy of Gibbs is confirmed by the fact that his measurements indicate harmonies among the principal Fraunhofer lines, as is shown in the following table. They all bear the test of Schuster's criterion, with the exception which was stated in the foregoing note.

Harmonies.	Gibbs.	Difference.
A 761.20	A 761.20	
$\frac{28}{31}$ A 687.54	B 687.49	.05
$\frac{64}{97}$ B 656.75	C 656.77	.02
$\frac{44}{75}$ C 589.73	D_γ 589.74	.01
$\frac{76}{85}$ D 527.29	E 527.38	.09
$\frac{89}{92}$ H_2 486.68	F 486.52	.16
$\frac{73}{21}$ H_2 431.24	G 431.03	.21
$\frac{15}{29}$ A 393.72	H_γ 393.59	.13

The greatest difference is only $\frac{1}{20}$ of one per cent., in the G line.

149. *Proper Use of Harmonic Tests.*

In systems of waves which are propagated with such frequency as the undulations of light, it may, perhaps, be impossible to devise any criterion which will show whether any two given waves are really harmonic. But if we consider that undulations which are not harmonic are continually tending to destroy each other, various useful tests may be found, which will serve as guides for the approximate determination of harmonies that must really exist. For example, if there are two harmonic light-waves, the slower oscillating 1670 times, while the swifter oscillates 1843 times, there will be more than 300,000,000,000 coincidences of phase per second, and yet Schuster's method would lead us to suppose that there is no harmony. The ratio $\frac{1670}{1843}$, is equivalent to .906131, which is between $\frac{29}{32}$ and $\frac{77}{85}$.

29 ÷ 32	.906250
77 ÷ 85	.905882
Difference	.000368
.906250 — .906131	.000119
Ratio of Differences 119 ÷ 368	.324
Probable Error	.250

150. *Successive Harmonies.*

The following table shows that Angstrom's measurements indicate harmonic undulations, which present more than 600,000,000,000 coincidences of phase per second in successive lines:

Wave-length.	Log. w. l.	Log. ratio,	Ratio.
A 760.09	2.8808650	$\bar{1}$.9755619	501 / 530
a 718.50	2.8564269	$\bar{1}$.9803266	410 / 429
B 686.68	2.8367535	$\bar{1}$.9802695	710 / 743
C 656.18	2.8170230	$\bar{1}$.9534617	389 / 433
D_1 589.50	2.7704847	$\bar{1}$.9512343	446 / 499

Wave-length.	Log. w. l.	Log. ratio,	Ratio.
E. 526.89	2.7217190	$\bar{1}$.9919387	427 / 435
b_4 517.20	2.7136577	$\bar{1}$.9730311	359 / 382
F 486.06	2.6866888	$\bar{1}$.9475091	288 / 325
G 430.72	2.6341979	$\bar{1}$.9787118	418 / 439
h 410.12	2.6129097	$\bar{1}$.9856655	149 / 154
H_1 396.80	2.5985752	$\bar{1}$.9961108	667 / 673
H_2 393.26	2.5946860		

Schellen's table gives 393.28 for the wave-length of H_2. His other values are precisely the same as the harmonic lengths which are given here. The greatest interval between the successive coincidences of phase in the propagation of the waves which represent any two adjacent lines, is less than $\frac{1}{50}$ of an inch.

Some of the closer lines precisely represent simple geometric progressions within the limits of uncertainty of observation. The middle D line, according to Gibbs, is a geometrical mean between the extreme lines.

Gibbs.	Geometric.	Log.
β 590.04	590.038	2.7708800
γ 589.74	589.736	2.7706576
α 589.43	589.434	2.7704352

By making $r = \frac{853}{852}$, we find that the three b lines are in geometrical progression :

Schellen.	Geometric.	Log.
b_1 518.30	ar_3 518.296	2.7145778
b_2 517.20	ar 517.209	2.7136658
b_3 516.67	a 516.666	2.7132098

Gibbs, in *Johnsons' Cyclopedia*, gives four b lines, the additional line being also geometrically determined :

Gibbs.	Geometric.	Log.
b_1 518.31	ar^3 518.31	2.7145896
b_2 517.22	ar 517.22	2.7136776
b_3 516.85	$ar^{\frac{1}{3}}$ 516.86	2.7133736
b_4 516.69	a 516.68	2.7132216

151. *Conjoined Harmonics.*

The indications of geometrical progression in the D and b groups suggest the propriety of looking for similar evidence among the remaining lines. The relations which I have pointed out between æthereal and planetary nodes (Note 37), led me to look to the inertia of Sun and Jupiter as an important source of nodal influence upon æthereal waves. Light-waves would traverse a trajectory equivalent to that of Earth's daily synodic rotation $5.202798 \times 365.25636 = 1900.355$ times, during the interval which would be required for them to traverse one equivalent to Ju-

piter's orbit. If we suppose the length of each wave to be increased in the ratio $r = (1901.355 \div 1900.355)^{\frac{1}{4}}$, we get the following approximations :

Geometric wave-lengths.		Log. w. l.	Log. r^n.	Schellen.
A	$= ar^{428}$ 760.10	2.8808707	.0244495	760.09
a	$= Br^{344}$ 718.49	2.8564212	.0196510	718.50
B	$= Cr^{345}$ 686.70	2.8367702	.0197081	686.68
C	$= D_1r^{815}$ 656.24	2.8170621	.0465569	656.18
D	$= Er^{854}$ 589.53	2.7705052	.0487848	589.50
E	$= b_2r^{141}$ 526.89	2.7217204	.0080546	526.89
b_2	$= Fr^{472}$ 517.21	2.7136658	.0269630	517.20
F	$= Gr^{919}$ 486.07	2.6867028	.0524979	486.06
G	$= hr^{373}$ 430.73	2.6342049	.0213076	430.72
h	$= H_1r^{251}$ 410.11	2.6128973	.0143384	410.12
H_1	$= H_2r^{68}$ 396.79	2.5985589	.0038845	396.80
H_2	393.26	2.5946744		393.28

The lines can be grouped in three sets :—1. A, a, B, D_1 ; 2. C, b_2, F, h ; 3. E, G, H_1, H_2. All members of the first and third groups are connected with the other members of their own groups by some power of r^4 ; those of the second group, by some power of r^2 ; the members of the third group being connected with those of the first by some odd power of r^2 ; those of the second with those of either of the other groups, by odd powers of r. Three lines of the middle group, C, F, h, are hydrogen lines. The boundaries of the group are phyllotactic ; $5\,C = 8\,h$.

152. *Interpretation and Mass-Relations.*

The considerations involved in the foregoing notes were orbital velocity $\left(v_0 \propto \sqrt{\frac{1}{r}}\right)$, gravitating velocity, $\left(v_1 = g \propto \frac{1}{r^2}\right)$, the constant velocity of light, (v_3) and inertia, or mass. Orbital velocity varies as the fourth root of gravitating velocity, $\left(v_0 \propto v_1^{\frac{1}{4}}\right)$; hence the ratio of increase varies as the fourth root of the relative disturbance of inertia, $r = (1901.355 \div 1900.355)^{\frac{1}{4}}$.

If we take the constant relation between gravitating and photodynamic action at Earth's surface as a unit, ($p_3 = 1$), there should be some harmonic relation between p_3 and Jupiter's incipient perturbation, ($p_5 = r^4 - 1$), dependent on the masses of Earth, (m_3), and Jupiter, (m_5). Earth's reaction upon its linear centre of oscillation, relative to the centre of the "line of force" which connects it with Jupiter, is exerted at ($\frac{1}{4}$ of $\frac{1}{3}$) $= \frac{1}{6}$ of the distance of Jupiter's action upon Earth, consequently with a six-fold relative efficiency. Accordingly we find :

$$\frac{m_3}{m_5} = \frac{6\,p_5}{p_3} = \frac{6}{1900.355} = \frac{1}{316.726}$$

$$\frac{m_0}{m_3} = 316.726 \times 1047.879 = 331890$$

$$\rho_3 = 92,796,300 \text{ miles.}$$

This value of ρ_3 differs by less than $\frac{1}{15}$ of one per cent. from the mean of various mechanical estimates, which was given in Note 15.

153. *Linear Harmonies.*

The harmonies to which Schuster refers, in the third conclusion of his summary, seem to be linear rather than geometric. If we omit the specially phyllotactic lines C and *h*, together with the secondary lines of the D and *b* groups, the percentages of the geometric, Schellen and Gibbs tables give the following coincidences of harmonic tendency:

	Geometric.		Schellen.		Gibbs.	
A	760.10	1933 — .16	760.09	1933 — .31	760.40	1933 + .38
a	718.49	1827 + .03	718.50	1827 — .06	718.47	1827 — .23
B	686.70	1746 + .21	686.68	1746 + .03	686.71	1746 + .02
D	589.53	1499 + .10	589.50	1499 — .07	589.51	1499 — .12
E	526.89	1340 — .18	526.89	1339 — .27	526.96	1340 — .16
b_2	517.21	1315 + .19	517.20	1315 + .09	517.22	1315 + .08
F	486.07	1236 + .03	486.06	1236 — .09	486.07	1236 — .12
G	430.73	1095 + .29	430.72	1095 + .20	430.73	1095 + .17
H_1	396.79	1009 — .02	396.86	1009 — .05	396.81	1099 — .02
H_2	393.26	1000	393.28	1000	393.30	1000

The only instances in which the deviations from exact harmony exceed $\frac{1}{4}$ of the right hand unit, are the G line in the geometric table, the A and E lines of Schellen, and the A line of Gibbs.

154. *Interstellar Phyllotaxy.*

The interstellar abscissas, Note 46, present the following phyllotactic features:

1. The determination of the paraboloid requires 3 abscissas.

2. The whole number of abscissas, between the vertex and the stellar region, is 3×13.

3. The abscissas between A_2 and A_{39} are divided into two groups, each group containing 2×3^2 abscissas.

4. Each group has two equal subdivisions; the inner representing tendencies to condensation, the outer giving no present evidence of such tendency, except in comets, meteors and possibly asteroids.

155. *Distance of a Centauri and its connection with the Interstellar Paraboloid.*

Newcomb gives estimates of the parallax of *α Centauri*, ranging between 0″.48 and 1″.96. The mean of Henderson's observations, in 1832–3, as deduced by himself, was 1″.16 ± .11. Peters, from the same observations, found 1″.14 ± .11. Henderson obtained 0″.913 from Maclear's observations in 1839–40; Peters, 0″.976 ± .064 from the same; Maclear, 0″.919 ± .034 from declinations in 1842, 1844 and 1848; Moesta, 0″.880 ± .068 from declinations in 1860–4. There is, therefore, an uncertainty as to the

actual distance, which is of the same order of magnitude as planetary eccentricities. If this fact should be thought to diminish the probability of a kinetic bond between the photodynamic paraboloid and the fixed stars, it will be well to bear in mind the following considerations :

1. If there is an all pervading interstellar medium, which is both material and elastic, all its persistent oscillations *must be* cyclically harmonic in some way or other.

2. All such permanent oscillations must be dependent upon or associated with permanent masses and velocities.

3. The mass and velocity from which the paraboloidal abscissas were deduced, are the mass of the sun and the velocity of light.

4. The coördinates indicate a solar motion in space, which is closely accordant with Herschel's estimated velocity. (Note 112.)

5. The abscissas locate regions of incipient subsidence, which account for the formation of the several planetary belts, in accordance with Herschel's interpretation of the nebular hypothesis.

6. The abscissas are manifoldly grouped, in ways that are phyllotactically and otherwise harmonically symmetrical, as might be looked for in a medium like the supposed luminiferous æther.

7. The last phyllotactic abscissa, A_{38}, is a fourth proportional to Sun's radius, Laplace's limit, and the solar modulus of light.

8. The paraboloid fixes Sun's position, relatively to some other important stars in the Milky Way. (Note 114.)

9. These are the most far-reaching indications of an unbroken chain of kinetic influences, that have ever been published.

10. Being based upon the greatest mass and the greatest intercosmical velocity of which we have any measurable knowledge, the law of parsimony gives an *a priori* presumption that the chain may extend to other masses of the same order of magnitude as the Sun.

11. The next abscissa to the solar phyllotactic series, A_{39}, is in the region of the fixed stars, its locus being, within the limit of probable error, ($\pm$ .25), the same as that of *α Centauri*.

12. The terminal locus is not only within, but *far* within, the limits of probable error. Its accordance with *α Centauri* may be exact ; it is almost impossible that the deviation from precise accordance can be so great as 8 per cent., and such a deviation could be easily explained by stellar orbital motions.

13. The second stellar abscissa, A_{40}, indicates a distance corresponding to Bessel's estimate of the parallax of 61 *Cygni*.

14. Whatever may be thought of the last three indications, the first ten are plain, unmistakable and incontrovertible.

156. *Correlations of Planetary Mass and Distance.*

Stockwell closes the introduction to his "Memoir on the Secular Variations of the Elements of the Orbits of the Eight Principal Planets," in the following words :

"The idea is thus suggested of the existence of a system of bodies in

which the masses of the different bodies are so adjusted to their mean distances as to insure to the system a greater degree of permanence than would be possible by any other distribution of masses. The mathematical expression of a criterion for such distribution of masses has not yet been fully developed; and the pending illustrations have been introduced here, more for the purpose of calling the attention of mathematicians and astronomers to this interesting problem than for any certain light we have yet been able to obtain in regard to its solution."

When I began my investigation of the harmonies which illustrate the laws of æthereal elasticity, the only published evidence of any connection between planetary mass and distance was Alexander's approximate equality between the products of the masses of Jupiter and Saturn by the squares of their respective major axes:

$$\text{Jupiter } \tfrac{1}{1047.879} \times 5.202798^2 = .025832.$$
$$\text{Saturn } \tfrac{1}{3501.6} \times 9.538852^2 = .025985.$$

Laplace, however, had indicated elements of stability in the sums of various products, and had demonstrated the tendency of approximate synchronisms to become exact; Herschel had shown that "subsidence, and the central aggregation consequent on subsidence, may go on quite as well among a multitude of discrete bodies under the influence of mutual attraction and feeble or partially opposing projectile motions, as among the particles of a gaseous fluid"; * various physical investigations, based upon propositions in Newton's Principia, had indicated the fact that *all persistent oscillations or cyclical motions in elastic media* MUST BE *subject to harmonic laws.*

In studying Herschel's statements of the nebular hypothesis, it soon became evident that Sun, at the principal centre of nucleation, Earth, at the centre of the belt of greatest condensation, and Jupiter, at the centre of the primitive nebula, had some important common relations which had exerted a controlling influence over the other cosmical masses. The four following are specially noteworthy.

1. The "nascent velocity" of Sun, $\frac{gt}{2}$†, *is equivalent to the velocity of light.*

2. The nascent velocities of Earth and Jupiter are nearly equal.

3. Earth's nascent velocity is about 3 per cent. less, while Jupiter's appears to be slightly greater, than the limit of possible circular-orbital velocity, $\sqrt{gr}$ at Sun's surface.

4. The aggregate orbital *vis viva* of Earth, vv_3, and Jupiter, vv_5, is a simple function of mean distance from Sun, d, and orbital time, $d^{\frac{3}{2}}$.

$$\left(\frac{d_5}{d_3}\right)^{\frac{5}{2}} = \left(\frac{5.202798}{1}\right)^{\frac{5}{2}} = 61.7436 = 1 + 60.7436 = vv_3 + vv_5 \quad (1)$$

**Outlines of Astronomy*, Sect. 871.

†t being time of solar rotation, and g being the acceleration of superficial gravitation.

In the above equation, and elsewhere in the present note, Earth's mass and semi-axis major are taken as the units of mass and distance.

In studying the results of nebular "subsidence," let α represent the locus of incipient belt-subsidence or secular aphelion; β, the locus of mean belt subsidence or mean aphelion; γ, the semi-axis major; δ, the mean locus of belt-rupture or mean perihelion; ε, the locus of incipient belt-rupture or secular perihelion; subscript 0, 1, 2, 3, 4, 5, 6, 7, 8, Sun and the principal planets in their order, Mercury, Venus, Earth, Mars, Jupiter, Saturn, Uranus, Neptune; m, mass.

$$m_0 : m_3 : : \varepsilon_3 : \varepsilon_0 : : 1047.879 : 1 \qquad (2)$$

According to Stockwell (op. cit. p. 38), $\varepsilon_3 = .9391726\,\gamma_3$. Therefore $\gamma_3 = 1047.879\ \varepsilon_0 \div (5.202798 \times .9391726) = 214.4513\ \varepsilon_0$ and $\gamma_5 = 1115.74\ \varepsilon_0$. Mass being represented by the product of mean orbital *vis viva* by mean distance, we find, from (1) and (2),

$$m_3 : m_5 : : 1 \times 1 : 60.7436 \times 5.202798 : : 1 : 316.0366 \qquad (3)$$
$$m_0 : m_3 : : (316.0366 \times 1047.879 = 331668) : 1 \qquad (4)$$

Earth's chief companion planet, Venus, shows the influence of incipient subsidence-aggregation.

$$m_3 : m_2 : : \gamma_3 : \alpha_2 : : 1 : .77442 \qquad (5)$$
$$m_0 : m_2 : : (331668 \div .77442 = 427630) : 1 \qquad (6)$$

Jupiter's chief companion planet, Saturn, shows the combined influence of modified belt-rupture and secular stability.

$$m_5 : m_6 : : \beta_5\gamma_5 : \beta_5\gamma_5 : : 9.077645 \times 9.538852 : 4.978245 \times 5.202798 : : 3.3432 : 1 \qquad (7)$$
$$m_0 : m_6 : : (3.3432 \times 1047.879 = 3503.22) : 1 \qquad (8)$$

The outer planet of the dense belt, Mars, shows the influence of modified subsidence at the centre of nebular planetary inertia (Saturn), combined with that of incipient subsidence at the centre of the belt (Earth).

$$m_3 : m_4 : : \beta_6 : \alpha_3 : : 10 : 1.0677352 : : 9.3657 : 1 \qquad (9)$$
$$m_0 : m_4 : : (9.3657 \times 331668 = 3101613) : 1 \qquad (10)$$

The two outer planets of the system show the combined influence of nodes of subsidence, rupture, and condensation.

$$m_8 : m_3 : : (\delta_8 - \alpha_3)\gamma_8 : (\delta_8 + \alpha_7)\gamma_3 : : (29.73235 - 1.06774) \times 30.03386 : (29.73235 + 20.679233) : : 17.0776 : 1 \qquad (11)$$
$$m_0 : m_8 : : (331668 \div 17.0776 = 19392) : 1 \qquad (12)$$
$$m_7 : m_3 : : (\beta_7 - \varepsilon_3)\ \gamma_7 : (\beta_7 + \delta_3)\ \gamma_3 : : (20.04418 - .93226) \times 19.18358 : (20.04418 + 4.97824) : : 14.6523 : 1 \qquad (13)$$
$$m_0 : m_7 : : (331668 \div 14.6523 = 22602) : 1 \qquad (14)$$

The accordance between the nodal and the computed values is shown in the following table:

		Nodal.	Computed.	Authority.
(2)	$m_0 \div m_5$	1047.879	1047.879	Bessel.
(4)	$m_0 \div m_3$	331668.	331776.	Chase.
(6)	$m_0 \div m_2$	427630.	427240.	Hill.
(8)	$m_0 \div m_6$	3503.22	3501.6	Bessel.
(10)	$m_0 \div m_4$	3101613.	3093500.	Hall.
(12)	$m_0 \div m_8$	19392.	19380.	Newcomb.
(14)	$m_0 \div m_7$	22602.	22600.	Newcomb.

The mean orbital *vis viva* which could be communicated to a subsiding particle in any given time, varies directly as the mean gravitating acceleration, $\left(\frac{1}{\gamma}\right)^2$, and inversely as the mean subsidence potential, $\left(\frac{1}{\beta}\right)$. The synchronism in the determination of the *vis viva* of the two chief planets is shown by the proportion

$$m_5 \gamma_6 : m_6 \gamma_5 : : \gamma_6^2 \beta_6 : \gamma_5^2 \beta_5 \qquad (15)$$

which is readily deduced from (7). The confirmation which this lends to Herschel's interpretation of the nebular hypothesis is very satisfactory,

The planets of the dense belt bear witness to an interesting combination of harmonic influences. The simple attraction of a principal centre of condensation would tend to produce radial oscillations and very elliptical orbital paths. If the central force could be concentrated in a point, the elliptic path would coincide with the major-axis and be rectilinear, its orbital time being $2\pi\sqrt{\frac{r}{g}}$ and the mean velocity being $\frac{2}{\pi}\sqrt{gr}$; g representing the acceleration of the central force at the distance r. If the radial oscillations are made circular, (through the mutual collision of particles, the exchange of molecular *vis viva* for *vis viva* of rotation or of revolution, external attraction and other physical disturbances), the orbital velocity should be some function of the nascent velocity, $\frac{gt}{2}$.

The combined orbital *vis viva* of Earth and Jupiter, (1), suggests the consideration of nebular subsidence from Moon's apogee towards the mean centre of gravity of Jupiter and Sun. In expanding or contracting nebulæ, rotating velocity and circular orbital *vis viva* both vary inversely as radius. In considering ultimate particles or chemical atoms of equal volume, the mass and the limiting or maximum acceleration both vary as the density; the limit of gravitating *vis viva*, therefore, varies as the cube of the density, ($\delta \times \delta^2 = \delta^3$) and centrifugal *vis viva* varies as $\frac{1}{\delta^3}$. Circular orbital or tangential atomic *vis viva* varies directly as density and

inversely as radius-vector, $(\delta \div \rho)$. Equating these two expressions for centrifugal energy, at the centre of condensation, we get

$$\frac{1}{\delta^2} \propto \frac{\delta}{\rho} \tag{16}$$

$$\delta \propto \rho^{\frac{1}{4}} \propto \frac{t^2}{\rho^3} \tag{17}$$

$$t^2 \propto \rho^{\frac{13}{4}} \propto \delta^{13} \tag{18}$$

The limit of circular-orbital time, $2\pi\sqrt{\frac{r}{g}}$, for Earth, is $t_3 = 5073.6$ seconds, Earth's orbital time being $t_1 = 1$ year $= 31558149$ seconds. If these times were fixed by the above relations of "subsidence" we should have

$$31558149^2 : 5073.6^2 :: \delta_a^{13} : \delta_o^{13} \tag{19}$$

$$\delta_a = 3.8341\ \delta_o \tag{20}$$

$$\rho_a : \rho_o :: \delta_a^4 : \delta_o^4 :: 216.0944 : 1 \tag{21}$$

Earth's present density, as deduced from the combined influences of subsidence, linear oscillation, conical oscillation and orbital velocity, (Notes 5, 23), is $3.9231\ \delta_o$, as is shown by the following calculations :

$$m_o = (2 \times 3 \times 4)^4\ m_3 = 331776\ m_3 \tag{22}$$

$$\rho_3 = (m_o \div m_3)^{\frac{1}{3}} \times (t_1 \div t_3)^{\frac{2}{3}} \times r_3 = 92{,}785{,}700 \text{ miles.} \tag{23}$$

$$\rho_o = \rho_3 \div 214.4472^* = 432673.8 \text{ miles.} \tag{24}$$

$$\left.\begin{array}{l} \delta_3 : \delta_0 :: m_3 \div r_3^3 : m_o \div \rho_o^3 :: 3.9231 : 1 \\ \text{or, from (20), (21) and (22), } \delta_3 : \delta_a :: 216.0944^3 : 214.4472^3 \\ \qquad :: 3.9231 : 3.8341 \\ \delta_3 : \delta_o : 3.9231 : 1 \end{array}\right\} \tag{25}$$

In (21) the radius of early lunar-telluric subsidence, ρ_a, includes:— α. Moon's orbital radius of incipient subsidence, or locus of apogee, $.5824\ \rho_o$; β. Earth's semi-axis major, $214.4472\ \rho_o$, (24); and γ. The semi-axis major of the centre of gravity of Sun and Jupiter, $1.0647\ \rho_o$.

α. According to Von Littrow, Moon's locus of apogee $= 1.054908 \times 60.2776 \times 3962.8 = 251{,}985$ miles $= .5824\ \rho_o$, (24).

γ. According to Stockwell, (Smithsonian Contrib., 232, p. 38), Jupiter's maximum eccentricity is .0608274. This gives, for the semi-axis major of the chief centre of gravity of the solar system, (Note 113), $\rho_o \div .9391826 = 1.064767\ \rho_o$.

The influence of nascent *vis viva*, at the centre of the belt of greatest condensation, is further shown by the relations which are maintained, with close approximation, between Earth and its adjacent planets.

Nascent velocity at Laplace's limit, and consequent orbital *vis viva*, is

* See Note 113.

π times as great as velocity of rotation at the same limit. This leaves $\pi - 1$ units of Earth's subsident rotating velocity to be converted into orbital *vis viva*. Taking Earth's mass and semi-axis major as the units of mass and distance, the foregoing relative theoretical values of nodal mass yield the following comparative results :—

	Orbital *Vis Viva* — Mass ÷ Rad. Vect.		Theoretical *Vis Viva*.	
Earth	$1 \div 1$	$= 1.$		$1.$
Venus	$(331668 \div 427630) \div .72333$	$= 1.0723$	$(\pi - 1) \div 2$	$= 1.0708$
Mars	$(331668 \div 3101613) \div 1.52369$	$= .0702$	$(\pi - 3) \div 2$	$= .0708$
		2.1425	$\pi - 1$	2.1416

(26)

The influences of *vis viva* which are represented by the two outer planets, (11) (13), are somewhat more intricate, but no less interesting than those of their companions. Orbital velocity, in the path of any given planet, varies inversely as radius vector, following the same law as variations of rotating velocity in an expanding or contracting nebula, and as variations of orbital *vis viva* in revolving particles at different distances from a controlling centre. Hence there are tendencies to maximum and mean accelerations and retardations at secular and mean apsides, which are shown in the amounts of nodal planetary aggregation that are required to maintain the cyclical equilibrium of orbital *vis viva*. The ratio of Neptune's *vis viva* to the mass at the chief centre of condensation, Earth, is determined by cardinal nodes of Neptune, Uranus and Earth ; the like ratio of the *vis viva* of Uranus, by cardinal nodes of Uranus, Jupiter and Earth. Earth's nodes are those of incipient subsidence and rupture at the centre of density, secular aphelion and perihelion ; the node of Uranus which is influential upon Neptune is that of incipient subsidence ; the three other nodes are of mean subsidence or rupture. Earth's secular aphelion has modified the aphelion planet, while its secular perihelion has modified the perihelion planet of the outer two-planet belt.

Atomic phyllotaxy, times and acquired velocities of subsidence, orbital velocities resulting from subsident *vis viva*, and the relations of density to distance from a controlling centre in an elastic medium, are all illustrated by the *exact* equality, (21) (23):—

$$(t_1 \div t_2)^{\frac{8}{15}} = \rho_a \div \rho_e \qquad (27)$$

The order of importance of the equilibrating manifestations of cosmical *vis viva* in the solar system, seems to be the following :—

1. The relation of Sun's mass to mass at principal centre of density, Earth, which satisfies necessary tendencies to subsidence, oscillation, and orbital revolution (22).

2. The combined orbital *vis viva* at the chief centre of density and at the centre of primitive nebulosity (1).

3. The incipient tendency to rupture, between the chief centres of nucleation and of nebulosity, Sun and Jupiter (2).

4. The relations of *vis viva* between the chief centres of density and of nebulosity, Earth and Jupiter (3).

5. The relations between mean tendencies to belt-rupture and to secular stability, between the chief centres of nebulosity and of planetary inertia, Jupiter and Saturn, in the chief belt of planetary aggregation (7).

6. The tendency of incipient subsidence towards the chief centre of nucleation, and of incipient rupture from the chief centre of density, Venus, Sun and Earth (5).

7. The tendency of incipient subsidence at the chief centre of density, together with mean tendencies of subsidence at the chief centre of planetary inertia, Earth, Saturn and Mars (9).

8. The combination of incipient tendencies of subsidence at the chief centre of density and at the inner margin of the outer planetary belt, with mean rupturing tendencies at the outer margin of the outer belt (11).

9. The combination of incipient tendencies of rupture at the chief centre of density, with mean rupturing tendencies at the chief centre of nebulosity and mean subsidence at the inner margin of the outer belt (13).

Mercury, with its great orbital eccentricity, the asteroids, comets and meteors, doubtless serve to complete the exact adjustment which the stability of the system requires.

157. *Relations of Fraunhofer Lines to Density and Vis Viva.*

Astronomers do not waste their time in inquiring whether planetary motions are in accordance with the laws of gravitation, neither need physicists ask whether cyclical undulations are harmonic. Knowing that they must be so, the wiser way is to question nature in order to find what the harmonics are. The simplest harmonies are those which are based on multiples of 2 or 3. If we take $\lambda = 392.78$ as a unit, we find the following approximation of wave-lengths, as measured by Gibbs, to harmonic values :

Harmonic.	Observed.	Error.	Probable Error.
$\frac{7}{4}\lambda = 687.37$	B 686.71	+0.66	± 24.54
$\frac{5}{3}\lambda = 654.63$	C 656.21	—1.58	± 32.73
$\frac{9}{4}\lambda = 589.17$	D_1 589.51	—0.34	± 24.54
$\frac{4}{3}\lambda = 523.71$	E 526.87	—3.16	± 32.73
$\frac{5}{4}\lambda = 490.97$	F 486.07	+4.90	± 24.54
$\frac{1}{4}\lambda \quad \frac{2}{3}\lambda = 392.78$	H_2 393.30	—0.52	± 32.73

The probable error, in each instance, is one-fourth of the harmonic divisor, in accordance with Schuster's proposed test. The greatest discrepancy, F, is only $\frac{1}{2}$ of the probable error, or only $\frac{1}{8}$ as great as we might look for without invalidating the evidence of harmonic influence. Such accordance is surely satisfactory enough to encourage further examination.

If we take $l = \frac{1}{24}\lambda$ as a unit, so as to provide for the requirements of centripetal, linear and conical oscillation, ($2 \times 3 \times 4$; see Notes 5, 23, 156), we find the following approximations :—

Harmonic.	Observed.	Error.
$46\,l = 752.83$	A 760.40	−7.57
$44\,l = 720.10$	a 718.47	+1.63
$42\,l = 687.37$	B 686.71	+0.66
$40\,l = 654.63$	C 656.21	−1.58
$36\,l = 589.17$	D_1 589.51	−0.34
$32\,l = 523.71$	E 526.87	−3.16
$30\,l = 490.97$	F 486.07	+4.90
$26\,l = 425.51$	G 430.73	−5.22
$25\,l = 409.15$	h 410.12	−0.97
$24\,l = 392.78$	H_2 393.30	−0.52

If the Fraunhofer lines are, like musical beats, due to the interference of waves which are very nearly but not exactly in unison, their proper investigation requires a consideration of more intricate harmonies than those which are based upon simple binary or ternary division. The harmonic A line seems to be attracted towards the simple octave of H_2, and H_1 indicates a reaction resulting from such attraction. For, if H_1 be divided into 12 parts, (3×4), and H_2 into 15 parts, (3×5), each of the submultiples will also be a submultiple of A, very nearly, if not exactly.

Harmonic.	Observed.	Error.	
$A_o = 760.38$	A 760.40	+.02	(1)
$\chi_1 = 396.72$	H_1 396.81	−.09	
$\chi_2 = 393.30$	H_2 393.30	.00	

$\chi_1 = \frac{1}{23}\,A_o$; $\chi_2 = \frac{1}{19}\,A_o$.

The line b_1 is very nearly $\frac{1}{3}$, or more nearly $\frac{64}{191}$ of H_1; the lines b_4, E, D_1, are very nearly $\frac{2}{11}$ (or about $\frac{2}{5}$), $\frac{14}{53}$ (or about $\frac{1}{4}$), and $\frac{2}{3}$ of H_2, respectively. In other words, H_1, b_1, A are nearly enough in the simple harmonic ratio 3, 4, 6, to produce luminous beats, or dark lines, while H_2, b_4, E, D_1, A, show a like approximation to 12, 15, 16, 18, 24.

The tendency of the harmonic ratios to become simply geometric, (Notes 41–43), is illustrated by approximations to the following equations: $B = \sqrt{a\,C}$; $D_1 = \sqrt{a\,F}$; $D_2 = \sqrt{C\,E}$; $b_1 = \sqrt{C\,h}$; $b_2 = \sqrt{b_1\,b_4}$; $H_1 = \sqrt{h\,H_2}$. The first of these equations gives the following accordances:

Harmonic.	Observed.	Error.	
$a = 718.51$	a 718.47	+.04	(2)
$\beta = \sqrt{a\,\gamma} = 686.67$	B 686.71	−.04	
$\gamma = 656.25$	C 656.21	+.04	

From (1) and (2) the harmonic series in the following table is constructed by using the exact harmonic ratios $\frac{2}{3}$, $\frac{4}{5}$, $\frac{5}{6}$, $\frac{6}{7}$, $\frac{6}{7}$, together with the disturbing ratios $\frac{42}{64}$, $\frac{56}{75}$, $\frac{16}{21}$, (which are all near enough to $\frac{2}{3}$ to produce luminous beats), and $\frac{37}{52}$ which is nearly equivalent to $\frac{5}{7}$. Four of the numbers which appear as terms of the exact harmonic ratios, (2, 3, 5, 8), belong to the phyllotactic series; one, $(6 = 2 \times 3)$, is the product of two adjacent phyllotactic factors; one, 7, is a prime number.

Harmonic.	Observed.	Error.
A_0 760.38	A 760.40	—.02
α 718.51	a 718.47	+.04
β 686.67	B 686.71	—.04
γ 656.25	C 656.21	+.04
δ 589.95	D_1 589.51	+.44
δ_2 588.57	D_2 588.91	—.34
ε 526.74	E 526.87	—.13
β_1 518.16	b_1 518.31	—.15
β_2 517.33	b_2 517.22	+.11
β_4 516.21	b_4 516.69	—.48
φ 486.11	F 486.07	+.04
ζ 431.11	G 430.73	+.38
η 410.16	h 410.12	+.04
χ_1 396.72	H_1 396.81	—.09
χ_2 393.30	H_2 393.30	.00

In the harmonic column, $\beta_1 = \frac{6}{11}\chi_1$; β_4, ε and δ_2, are obtained by multiplying χ_2 by $\frac{3}{11}$, $\frac{7}{15}$ and $\frac{5}{7}$, respectively; $\zeta = \frac{3}{5}\alpha$, and $\beta_2 = \frac{6}{5}\zeta$; $\eta = \frac{5}{8}\gamma$ and $\varphi = \frac{5}{7}\eta$; $\delta_2 = \frac{5}{7}\beta$. All the differences between the harmonic and the observed values are unquestionably within the limits of probable errors of observation, as indicated by the different relative estimates of lines in metallic spectra by different observers.

The influence of relative *vis viva* between the chief centres of density and of nucleation, Earth and Sun, is shown both by the spectrum and by the mean rupturing loci of the principal planetary masses, Jupiter and Saturn. Such influence is a necessary consequence of the equality of action and reaction in the interchanges of æthereal, molecular and cosmical *vis viva*. The sum, or the mean of all the gravitating accelerations upon the æthereal particles in a radius vector by each of two mutually attracting bodies, is proportioned to their respective masses, $g \propto m$. The resulting mean *vis viva* of subsidence, mg^2, is proportioned to the cubes of the masses. Nascent *vis viva* is $\pi^2 \times$ orbital *vis viva*, or $\pi^2 \times$ representative orbital projection against uniform æthereal resistance, or $2\pi \times$ the corresponding nascent projection. If we take the theoretical oscillatory ratio between the masses at the chief centres of density and nucleation, $m_0 = 331776\ m_3$; $\rho_3 = 92785700$ miles $= 149320000000$ metres. Hence the proportions:

$$149320000000 : 331776^3 :: \pi^2 : .00000000041432$$
$$149320000000 : 331776^3 :: 2\pi : .00000000065073$$

Both of these values represent spectral wave-lengths, one being about one per cent. greater than h, the other about $\frac{2}{3}$ of one per cent less than C. The ratio between the values, $\frac{\pi}{2}$, is to the ratio of C to h, $\frac{2}{3}$, as Sun's semi-diameter, 1, is to the mean rupturing radius-vector of the centre of gravity of Sun and Jupiter, 1.01859. The projectile ratio of 414.32 from h, .01014, is to the projectile ratio of C from 650.73, .00848, as Jupiter's mean projection from Sun, 5.203, is to Saturn's mean projection from Jupiter, 4.336, within $\frac{1}{4}$ of one cent.

The Names of the Gods in the Kiche Myths, Central America. By Daniel G. Brinton, M.D.

(*Read before the American Philosophical Society, November 4, 1881.*)

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Of the ancient races of America, those which approached the nearest to a civilized condition spoke related dialects of a tongue, which from its principal members has been called the "Maya-Kiche" linguistic stock. Even to-day, it is estimated that about half a million persons use these dialects. They are scattered over Yucatan, Guatemala and the adjacent territory, and one branch formerly occupied the hot lowlands on the Gulf of Mexico, north of Vera Cruz.

Of the sixteen different dialects into which this stock has been divided, the Maya was considered by that eminent authority, the late Dr. C. H. Berendt, to be the purest example; although it has also been asserted that the most archaic forms and structure are to be found in the Zakloh-Pakab, otherwise called the Mam, spoken in a portion of the province of Soconusco and Chiapas, by a tribe which alone of these natives, so far as I know, claimed to be autochthonous. The Mam is agglutinative, and its grammatical structure is complex, traits much less marked in the other members of the group.

The so-called "metropolitan" dialects are those spoken relatively near the city of Guatemala, and include the Cakchiquel, the Kiche, the Pokonchi and the Tzutuhil. They are quite closely allied, and are mutually intelligible, resembling each other about as much as did in ancient Greece the Attic, Ionic and Doric dialects. These closely related members of the Maya-Kiche family will be referred to under the sub-title of the Kiche-Cakchiquel dialects.

There are well defined phonetic laws which have governed the growth of all these dialects, and several of them have been clearly set forth by M. Hyacinthe de Charencey in a comparative study published some years ago.* In regard to their phonetic system, it may be said that it is charac-

* *Recherches sur les Lois Phonétiques dans les Idiomes de la Famille Mame-Huastèque.* Revue de Linguistique, Tome v.

terized by numerous harsh gutturals, by hissing sounds, and explosive or "detonating" consonants, which strike most European ears disagreeably, and in the alphabetic representation of which there is no uniformity among authors.*

The civilization of these people was such that they used various mnemonic signs, approaching our alphabet, to record and recall their mythology and history. Fragments, more or less complete, of these traditions have been preserved. The most notable of these is the National Legend of the Kiches of Guatemala, the so-called *Popol Vuh*. It was written at an unknown date in the Kiche dialect by a native who was familiar with the ancient records. A Spanish translation of it was made early in the last century by a Spanish priest, Father Francisco Ximenez, and was first published at Vienna, 1857.† In 1861 the original text was printed in Paris, with a French translation, by the care of the late eminent Americanist, the Abbé Brasseur (de Bourbourg). This original covers about 175 octavo pages, and is therefore highly important as a linguistic as well as an archæological monument.

Both these translations are justly open to criticism. It needs but little study to see that they are both strongly colored by the view which the respective translators entertained of the purpose of the original. Ximenez thought it was principally a satire of the devil on Christianity, and a snare spread by him to entrap souls; Brasseur believed it to be a history of the ancient wars of the Kiches, and frequently carries his Euhemerism so far as to distort the sense of the original.

What has added to the difficulty of correcting these erroneous impressions is the extreme paucity of material for studying the Kiche. A grammar written by Ximenez has indeed been published, but no dictionary is available, if we except a brief "Vocabulary of the Principal Roots" of these dialects by the same author, which is almost useless for critical purposes.

It is not surprising, therefore, that some writers have regarded this legend with suspicion, and have spoken of it as but little better than a late romance concocted by a shrewd native, who borrowed many of his incidents from Christian teachings. Such an opinion will pass away when

* After some hesitation I have adopted the orthography *Kiche* instead of the more usual *Quiche*. The initial letter is in fact neither *k* nor *q*, but a rough guttural represented by a peculiar letter in the manuscripts, and for the sound of which we have nothing to correspond in European alphabets. Dr. Berendt transliterated the name as *Kiche;* and apart from its being on the whole more correct, it prevents confusion with the Qquichua of Peru. *Kiche* is a compound of *kiy* or *kij*, much, many, and *che* trees. The orthography adopted by Mr. A. F. Bandelier, and credited by him to Dr. Berendt, to wit, *QQuiché* (*Twelfth Annual Report of the Peabody Museum*, p. 629, note) was not used by Dr. Berendt, and should not be adopted, as it is without authority, and increases the liability of confusion with the Peruvian language.

† *Las Historias del Origen de los Indios de esta Provincia de Guatemala.* Por el R. P. F. Francisco Ximenez.

the original is accurately translated. To one familiar with native American myths, this one bears undeniable marks of its aboriginal origin. Its frequent puerilities and inanities, its generally low and coarse range of thought and expression, its occasional loftiness of both, its strange metaphors, and the prominence of strictly heathen names and potencies, bring it into unmistakable relationship to the true native myth. This especially holds good of the first two-thirds of it which are entirely mythological.

As a contribution to the study of this interesting monument, I shall undertake to analyze the proper names of the divinities which appear in its pages. The especial facility that I have for doing so is furnished by two MSS. Vocabularies of the Cakchiquel dialect, presented to the library of the American Philosophical Society by the Governor of Guatemala in 1836. One of these was written in 1651, by Father Thomas Coto, and was based on the previous work of Father Francisco Varea. It is Spanish-Cakchiquel only, and the final pages, together with a grammar and an essay on the native Calendar, promised in the body of the work, are unfortunately missing. What remains, however, makes a folio volume of 972 double columned pages, and contains a mass of information about the language. As no part of it has ever been published, I shall quote freely from it. The second MSS. is a copy of the Cakchiquel-Spanish Vocabulary of Varea made by Fray Francisco Ceron in 1699. It is a quarto of 493 pages. I have also in my possession copies of the *Compendio de Nombres en Lengua Cakchiquel*, by P. F. Pantaleon de Guzman (1704), and of the *Arte y Vocabulario de la Lengua Cakchiquel*, by the R. P. F. Benito de Villacañas, composed about 1580, as well as a copy of the *Memorial de Tecpan-Atitlan*, an important record written about the middle of the 16th century by a member of the royal Cakchiquel house of the Xahila. These formed part of the invaluable collection left by the late Dr. C. Hermann Berendt, and have aided me in my researches.

Father Coto himself tells us that the natives loved to tell long stories, and to repeat chants, keeping time to them in their dances. These chants were called *nugum tzih*, garlands of words, from *tzih*, word, and *nug*, to fasten flowers into wreaths, to set in order a dance, to arrange the heads of a discourse, etc. As preserved to us in the Popol Vuh, the rhythmical form is mostly lost, but here and there one finds passages, retained intact by memory no doubt, where a distinct balance in diction, and an effort at harmony is readily noted.

The name *Popol Vuh* given to this work is that applied by the natives themselves. It is translated by Ximenez "libro del comun," by Brasseur "livre national." The word *popol* is applied to something held in common ownership by a number; thus food belonging to a number is *popol naim;* a task to be worked out by many, *popol zamah;* the native council where the elders met to discuss public affairs was *popol tzih*, the common speech or talk. The word *pop* means the mat or rug of woven rushes or bark on which the family or company sat, and it is possible that

from the community of interests thus typified, the word came to mean anything in common.*

Vuh or *uuh* is in Kiche and Cakchiquel the word for *paper* and *book*. It is an original term in these and connected dialects, the Maya having *wooh*, a letter, writing; *uoch*, to write.

The opening words of the Popol Vuh introduce us at once to the mighty and mysterious divinity who is the source and cause of all things, and to the original couple, male and female, who in their persons and their powers typify the sexual and reproductive principle of organic life. These words are as follows:

"We are to bring forward the manifestation, the revelation, "the declaration of that which was hidden, the enlightenment "caused by Him who Creates, Him who fashions creatures, "Her who bears sons, Him who begets sons, whose names are "Hun-Ahpu-Vuch, Hun-Ahpu-Utiu, Zaki-Nima-Tzyiz, Tepeu, "Gucumatz, Qux-cho, Qux-palo, Ah-raxa-lak, Ah-raxa-sel.

"And along with Him are sung and celebrated in the Kiche "histories, those who are called the ancestress and the ances- "tor, by name Xpiyacoc, Xmucane, the preserver, the protec- "tor; twice over grandmother, twice over grandfather."

It will be here observed that the declaration of the attributes of the highest divinity embraces distinctly sexual ideas, and in consequence either of a confusion of thought or else of a deliberate purpose to which we find numerous parallels in Grecian, Egyptian and Oriental mythology, this divinity is represented as embracing the powers and functions of both sexes in his own person; and it is curious that both here and in the second paragraph, the *female* attributes are named *first*.

The word *Alom*, her who bears sons, or has sons (*la muger que tiene hijos*, Coto) is from the verbal form *alah*, to bring forth children, itself from the primitive *al*, the word in all this group of languages applied *by the woman only* to her son. The father used an entirely different word, to wit, *gahol*. The active form of this, *Gaholom* $\binom{c}{c}$ a holom) is that translated, He who begets sons.

First in the specific names of divinity given is *Hun-ahpu-vuch*. To derive any appropriate signification for this has completely baffled all previous students of this mythology. *Hun* is the numeral *one*, but which also, as in most tongues, has the other meanings of first, foremost, self, unique, most prominent, "the one," etc. *Ah pu* is derived both by Ximenez and Brasseur from the prefix *ah*, which is used to signify knowledge or posses-

*The meaning "a gathering of leaves" assigned to the words *popol vuh*, by Mr. A. F. Bandelier in a recent paper (*Transactions of the American Assoc. Ad. Sciences*, Vol. xxvii, p. 328), I should, perhaps, mention, in order to say that it is quite imaginary and groundless.

sion of, control over, mastership or skill in, origin from or practice in that to which it is prefixed; and *ub*, or *pub*, the *sarbacana* or blowpipe, which these Indians used to employ as a weapon in war and the chase. *Ah pu*, therefore, they take to mean, He who is skilled in using the sarbacane. *Vuch*, the last member of this compound name, is understood by both to mean a species of fox, the *tlacuatzin* of the Mexicans, which is the Opossum.

In accordance with these derivations Ximenez translates the name *Un tirador tacuasin*, and Brasseur, *Un Tireur de Sarbacane au Sarigue.*

Such a name bears little meaning in this relation; little relevancy to the nature and functions of God; and if a more appropriate and not less plausible composition could be suggested, it would have strong intrinsic claims for adoption. There is such a composition, and it is this: The derivation of Ahpu from *ah-pub* is not only unnecessary but hardly defensible. It is true that in Cakchiquel the sarbacane is *pub*, but in Kiche the initial *p* is dropped, as can be seen in many passages of the Popol Vuh, but, this apart, the true composition of this word I take to be unquestionably *ah-puz*, for *puz* has a distinctly relative signification, one intimately associated with the most recondite mysteries of religion; it expressed the divine power which the priests and prophets claimed to have received from the gods, and the essentially supernatural attributes of divinity itself. It was the word which at first the natives applied to the power of the forgiving of sins claimed by the Catholic missionaries; but the word was associated with so many wholly heathen notions that the *padres* decided to drop it altogether from religious language, and to give it the meaning of necromancy and unholy power. Thus Coto gives it as the Cakchiquel word for *Magica*, *Nigromantica*, and under the word *Poder*, has this interesting entry:

"**Poder:** *vziniçabal*, vel *vzintaçibal;* deste nombre usa la *Cartilla* en el "Credo para decir por obra vel poder del Spirito Santo. Al poder que "tienen los Sacerdotes de perdonar pecados y dar sacramentos, se "llaman, o an llamado, *puz, naual.* Asi el Pe Varea en su *Diccionario* "y el Sancto Vico en la *Theologia Indorum* usa en muchas partes destos "vocablos en este sentido. Ya no estan tan en uso, pues entienden por "el nombre *poder* y *vzintaçibal;* y son vocablos que antiguamente aplica- "ban a sus idolos, y oy se procura que vayan olbidando todo aquello "con que se les puede hacer memoria dellos."

The word *puz* is used in various passages of the Popol Vuh to express the supernatural power of the gods and priests, but probably by the time that Ximenez wrote it had, in the current dialect of his parish, lost its highest signification, and hence it did not suggest itself to him as the true derivation of the name I am discussing.

The third term *Vuch* or *Vugh* was chosen according to Ximenez, because this species of fox is notoriously cunning, "*por su astucia.*" It seems to me on the whole probable that this is correct, and that we have here a reminiscence of an animal myth, such as we might suppose in an early stage of civilization might have grown out of the story of Reynard

the Fox. It is certain that cunning and astuteness in small things are traits of character exceedingly admired by the vulgar and uneducated everywhere, and it is quite possible that they came to be looked upon as appropriate attributes of the highest conceivable divinity, as, indeed, there is no doubt but that they were among the Algonkin and other hunting tribes of the North.

But while, as I say, I am inclined to accept the rendering of *Vugh* as the tlacuatzin, it has not this meaning only, but several others, some of which are so suggestive that I shall quote what Father Coto has to say on the subject under the word *Raposo*, so that the reader may adopt another meaning if he chooses.

"**Raposo:** *xivan;* estos son los mas parescidos a los de España. * * *; "otro genero que come gallinas, el Mexicano le llama tacuatçin; a este "llaman *Vugh;* y nota que este mesmo nombre tiene un genero de baile "en que con los pies dan bueltas a un palo; tambien significa el temblor "de cuerpo que da con la terciana, o la misma çission; significa asi "mesmo quando quiere ya amanescer aquel ponerse escuro el ciclo; "tambien quando suele estar el agua del rio o laguna, por antiparastas- "sis, caliente, al tal calorsillo llaman *Vugh.*"

Of these various meanings one is tempted to take that which applies the word to "the darkness that comes before the dawn," and connect Hun-ahpu-vuch with the auroral gods, the forerunners of the light, like the "Kichigouai, those who make the day," of Algonkin mythology.

There is a curious passage in the Popol Vuh which might be brought up in support of such an opinion. It occurs at a certain period of the history of the mythical hero Hunahpu. The text reads:

"Are cut ta chi r'ah zakiric,	"And now it was about to become white,
"Chi zaktarin,	And the dawn came,
"U xecah ca xaquinuchic.	The day opened.
"Ama x-u ch'ux ri vuch?	'Is the fox about to be?'
"Ve, x-cha ri mama,	Yes, answered the old man.
"Ta chi xaquinic;	Then he spread apart his legs;
"Qate ta chi gekumar chic;	Again the darkness appeared;
"Cahmul xaquin ri mama.	Four times the old man spread his legs.
"Ca xaquin-Vuch," ca cha vinak vacamic.	"Now the Fox spread his legs," say the people yet (meaning that the day approaches).

This passage, says the Abbé Brasseur in his note to the page, "conceals a mystery having relation to the ancient genesiac theories of Mexico and Central America."

The double meaning in this text depends partly on the verb *xaquinuchic.* The Abbé says: "*Xaquin* signifie ouvrir les jambes, et *uch* ou *vuch* est le sarigue. Pour exprimer que le jour parut, on dit textuellement, le sarigue entr'ouvre les jambes." This word is from the same root as the Maya *Xach,* to spread the feet apart, *xacunah,* to spread the legs (Pio Perez, *Diccionario*): Cakchiquel, *tin xacaba va,* I spread my legs (*Yo abro*

las piernas, Coto, *Vocabulario.*) A modification of the root, to wit, *q'aq*, means to open, generally, a door, window, etc.

The Abbé adds that the expression referred to by the writer of the Popol Vuh as a common one to express the approach of day is no longer in use; but it had not become obsolete in Coto's time, as the following passage shows:

"**Escuridad:** una que ay quando quiere amanescer, *vugh; tan ti xakin "vugh."*

Here we have the precise expression under consideration, and as it is also given by Guzman (*Compendio de Nombres*, p. 22) it is probably an error of Brasseur's to consider it obsolete.

So long, however, as there is no further evidence to support the identity of Hun-ahpu-vuch with the dawn-heroes, we may reasonably explain this supposed genesiac myth as based on the homophony of *vuch*, fox, and *vuch*, the darkening before dawn. This homophony contains, indeed, rich material for the development of an animal myth, identifying the fox with the God of Light, just as the similarity of the Algonkin *waubisch*, the dawn, and *waubos*, the rabbit, gave occasion to a whole cycle of curious myths in which the Great Hare or the Mighty Rabbit figures as the Creator of the World, the Day Maker, and the chief God of the widely spread Algonkin tribes.*

The result of the above analysis is to assign Hun-ahpu-vuch the signification: "The One (or chief) master of supernatural power, the Opossum."

A main reason why I retain the meaning Opossum is that the names which follow are unquestionably derived from animals. The second is *Hun-Ahpu-Utiu*. The last factor, *utiu* is the wolf, the coyote, an animal which plays most important parts in the native cosmogonical myths all through the Californian, Mexican and Central American tribes. In the *Records from Teepan Atitlan* it is related that when man was first formed by the power of the sacred Chay Abah, the knife-stone or obsidian, and placed in the earthly paradise Paxil (the derivation of which name I shall consider later) there came the coyote, *utiu*, and the crow, *kooch*, and were about to destroy the maize harvests, but the coyote was killed, and thus the grain was saved. The remaining elements being the same I paraphrase this:

"The One (or chief) master of supernatural power, the Coyote."

In the third name, *Zaki Nima Tzyiz*, the first two words mean respectively *White, great;* the third is the common name for the pizote or badger, an active little animal quite familiar to the Indians, and the name of which, as we are informed by Father Coto, was currently applied to an active, lively lad. His words are:

"**Pizote:** vn animalejo como el tejon, o el mesmo, *çiz*; son caserositos,

* I have traced the growth of this myth in detail in *The Myths of the New World, a Treatise on the Symbolism and Mythology of the Red Race of America, Chap. VI.* (*New York*, 1876).

"cogen pequenos, y trauiesos mucho, y de aqueste animal toman el decir "quando vn muchacho es travieso, *çizulah aqual*, etc."

These are the translations given by Ximenez: "grandemente agudo pizote," "very active pizote," and "blanco pizote," "white pizote." But Brasseur derives *tzyiz* from *tzizo*, to sew, and, in a religious sense, to draw blood by pricking, a sacrificial custom of those countries, for which he adduces the authority of the MSS. Kiche vocabulary of Basseta; "Sangrarse para sacrificar á los idolos." He therefore translates: "Grand Blanc Piqueur;" but this seems inadmissible, as "the one who sews or pricks" is expressed by *tzizom* or *tzizonel* (*Coto*, s. v. *Coser*). We must therefore include this among the animal names.

Although not contained in the paragraph quoted, I here bring under consideration another animal name which elsewhere in the Popol Vuh is used as synonymous with the above. Thus (p. 30) we have this invócation:

"Make known your name, Hun-ahpu-vuch, Hun-ahpu-utiu,
"twice over bearer of children, twice over begetter of children,
"Nim-ak, Nim-tzyiz, master of the emerald," etc.

The name *Nim-ak* is elsewhere given *Zaki-nim-ak*. The former means "Great Hog," the latter "White, Great Hog." Brasseur translates *ak* as wild boar (*sanglier*), but it is the common generic name for the hog, without distinction of sex. In a later passage (p. 40), we are informed that it was the name of an old man with white hair, and that Zaki-nima-tzyiz was the name of an old woman, his wife, all bent and doubled up with age, but both beings of marvelous magic power. Thus we find here an almost unique example of the deification of the hog; for once, this useful animal, generally despised in mythology and anathematized in religion, is given the highest pedestal in the Pantheon.

We should probably understand these and similar brute gods to be relics of a primitive form of totemic worship, such as was found in vigor among some of the northern tribes. Various other indications of this can be discovered among the branches of the Maya family. The Cakchiquels were called "the people of the bat" (*zoq'*), that animal being their national sign or token, and also the symbol of their god (*Popol Vuh*, p. 225, 249). The *tucur* owl, *chan* or *cumatz* serpent, *balam* tiger, and *geh* deer, are other animals whose names are applied to prominent families or tribes in these nearly related myths.

The priests and rulers also assumed frequently the names of animals, and some pretended to be able to transform themselves into them at will. Thus it is said of Gucumatz Cotuha, fifth king of the Kiches, that he transformed himself into an eagle, into a tiger, into a serpent, and into coagulated blood (p. 314). In their dances and other sacred ceremonies they used hideous masks, carved, painted and ornamented to represent the heads of eagles, tigers, etc. These were called *goh*, as *cohbal ruvi cot*,

the mask of an eagle, *cohbal ruvi balam ;* the mask of a tiger, etc. (Coto, s. v. *Mascara* vel *Caratula.*) In Maya the same word is found, *Koh,* and in the Codex Troano, one of the few original Maya manuscripts we have left, these masks are easily distinguished on the heads of many of the persons represented. Recent observers tell us that in the more remote parishes in Central America these hideous brute faced masks are still worn by the Indians who dance in accompanying the processions of the Church !* Even yet, every new-born child among the Kiches, is solemnly named after some beast by the native "medicine man" before he is baptized by the Padre.†

This brings me to a name which has very curious meanings, to wit, *Tepeu.* It is the ordinary word in these dialects for Lord, Ruler, Chief or King. Its form in Cakchiquel is *Tepex,* in Maya *Tepal,* and it is probably from the adjective root *tep,* filled up, supplied in abundance, satisfied (colmado, satisfecho, que tiene sufficiente, Brasseur, *Vocabulaire Maya-Francais et Español*). In Kiche and Cakchiquel it is used synonymously with *galel* or *gagal* and *ahau* as a translation of Señor or Cacique. But it has another definite meaning, and that is, the disease *syphilis, the buboes* or *pox!* And what is not less curious, this meaning extends also in a measure to *galel* and *ahau.*

This extraordinary collocation of ideas did not escape the notice of Ximenez, and he undertakes to explain it by suggesting that as syphilis arises from cohabitation with many different women, and this is a privilege only of the great and powerful, so the name came to be applied to the chiefs and nobles, and to their god. But I shall give this explanation in his own words :

"Y tambien como à Dios se le dan muchos epitetos de grande, de sabio "y otras cosas, le dan el nombre de Tepeu, este significa las bubas, y en "su gentilidad era grandeza de los Señores el tenirlos, porque era señal "de mas poder para cohabitar con muchas mugeres de adonde se suelen "contraer, cosa que la gente ordinaria no podia."‡

Of course, syphilis has no such origin, but if the Indians thought it had, and considered it a proof of extraordinary genetic power, it would be a plausible supposition that they applied this term to their divinity as being the type of the fecundating principle. But the original sense of the adjective *tep* does not seem to bear this out, and it would rather appear that the employment of the word as the name of the disease was a later and secondary sense. Such is the opinion of Father Coto who says that the term was applied jestingly to those suffering from syphilitic sores because, like a chieftain or a noble, they did no work, but had to sit still with their hands in their laps, as it were, waiting to get well ; and when they had

* *Die Indianer von Santa Catalina Istlavacan ; ein Beitrag zur Culturgeschichte der Urbewohner Central Amerikas.* Von Dr. Karl. Scherzer, p. 9 (Wien. 1856).

†Ibid, p. 11.

‡ *Escolios à las Historias del Origen de los Indios,* pag. 157.

recovered it was satirically said of them that they had given up their sovereignty. To quote his words :

"**Bubas:** *galel* vel *tepex.* * * Quando an pasado dicen *xin colah* "*ahauarem*, id est, ya an dejado su señoria, porque el que las tiene se "esta sentado, sin hacer cosa, como si fuese señor ō señora.

"**Señora:** *xogohau ;* Señoria, *xogoñauarem* * * Deste nombre *xogo-* "*hau* vsan metaphoricamente para decir que una muger moza tiene "bubas ; porque se esta sin hacer cosa, mano sobre mano, * * y "quando a sanado de la enfermedad, dicen, si es varon : *xucolah* "*rahauarem achi rumal tepex. Tepex* es la enfermedad de bubas."

I should not omit to remark that this strange association of ideas is not confined to the dialects of which I am speaking. It occurs not unfrequently. In Maya, *ku* is the earliest and broadest name for divinity: *kukul* is to worship, and it also means a scab or sore. As in Kiche *puh* means the pus or matter from a sore, the term *ahpu* applied to the highest god may also mean, "he who has running sores." Furthermore, in the Aztec tongue *nanahuatl* means a person suffering from syphilis ; it is also, in a myth preserved by Sahagun, the name of the Sun God, and it is related of him that as a sacrifice, before becoming the sun, he threw into the sacrificial flames, not precious gifts, as the custom was, but the scabs from his sores.* So also Caracaracol, a prominent figure in Haytian mythology is represented as suffering from sores or buboes.

The name *Gucumatz* is correctly stated by Ximenez to be capable of two derivations. The first takes it from *gugum*, a feather ; *tin gugumah*, I embroider or cover with feathers (enplumar algo, como ponen en los guaypiles, etc. Coto. S. v. *Pluma*). The second derivation is from *gug*, feather, and *cumatz*, the generic name for serpent. The first of these is that which the writer of the Popol Vuh preferred, as appears from his expression : "They are folded in the feathers (*gug*), the green ones ; there- "fore their name is Gugumatz ; very wise indeed are they (p. 6)." The brilliant plumage of the tropical birds was constantly used by these tribes as ornament for their clothing and their idols, and the possession of many of these exquisite feathers was a matter of much pride and pleasure. The

*Boturini gives a moral coloring to this myth, which most likely it did not originally have. His version is that at the time of the Second Age, the gods gathered together all the people to reward them for their virtue, and ordered those who felt themselves meritorious enough to cast themselves into a fire, and thus attain celestial rewards. They began to debate who first should take the leap. While they were thus disputing the god Centeotl-inopitlzin (esto es, el dios huerfano, solo y sin padres) appeared to one who was sick, Nana-huatzin (el buboso, el podrido) and said: "What do you do here? Do you not see that your companions are engaged in vain disputes? Fling yourself into the flames and thus rid yourself of the sufferings which for years you have borne with heroism, and gain immortal honor." Inspired by these words, Nana-huatzin sprang into the flames, and his companions watched him consume. Then an eagle descended from heaven and carried his ashes to the sky where he became Tonatiuh, the Sun. Boturini Benaducci, *Idea de una Nueva Historia General de la Ameri a Septentrional*, pp. 37, 38 (Madrid, 1746).

long green ones especially called *gug* (properly $\overset{c}{c}u\overset{c}{c}$) were paid as tribute by the inferior chiefs (Varea, *Vocabulario*, s. v.).

A less likely derivation is from $chu\overset{c}{c}a$, strong or strength, and *cumatz*, the Strong Serpent. Probably "decorated with feathers" is the correct interpretation. Gucumatz is said by Mr. H. H. Bancroft to be "the acknowledged representative of Quetzalcoatl,"* a hasty statement, as the name is hardly more than a common adjective equivalent to royal or magnificent.

The names *Qux cho*, *Qux palo*, mean "the Heart of the Lake, the Heart of the Sea." To them may be added *Qux cah*, "the Heart of the Sky," and *Qux uleu*, "the Heart of the Earth," found elsewhere in the Popol Vuh (pp. 8, 12), and applied to divinity. The literal or physical sense of the word heart was, however, not that which was intended; in those dialects this word has a much richer metaphorical meaning than in our tongue; with them it stood for all the psychical powers, the memory, will and reasoning faculties, the life, the spirit, the soul. This is fully set forth by Coto:

"**Corazon,** *gux*. * * Atribuenle todos los affectos de las potencias, "memoria y entendimiento y voluntad, * * unde *ahgux*, el cuida- "doso, entendido, memorioso * *; toman este nombre *gux* por el "alma de la persona, y por el spirito vital de todo viviente, v. g. *xel ru* "*gux Pedro*, murió Pedro, vel, salio el alma de Pedro. * * deste "nombre *gux* se forma el verbo *tin gux lah*, por pensar, cuidar, "imaginar."

It would be more correct therefore, to render these names the "Spirit" or "Soul" of the lake, etc., than the "Heart." They represent broadly the doctrine of "animism" as held by these people, and generally by man in his early stages of religious development. They indicate also a dimly understood sense of the unity of spirit or energy in the different manifestations of organic and inorganic existence.

This was not peculiar to the tribes under consideration. The heart was very generally looked upon, not only as the seat of life, but as the source of the feelings, intellect and passions, the very soul itself.† Hence, in sacrificing victims it was torn out and offered to the god as representing the immaterial part of the individual, that which survived the death of the body.

The last two names in the paragraph quoted are *Ah-raxa-lak*, *Ah-raxa-sel*. To these Brasseur gives the high sounding renderings, "Master of the verdant Planisphere," "Master of the azure Surface." The literal translation is in laughable contrast to these turgid epithets; strictly speak-

* *Native Races of the Pacific Coast*, Vol. III, p. 477, note.

† "De adonde" remarks Granados y Galvez, "viene que mis Otomites, de una misma manera llaman á la alma que al corazon, aplicandoles á entrambos la voz *muy*." *Tardes Americanas*, Tarde iv, p. 101. (Mexico, 1778.)

ing they signify. "He of the green dish," "He of the green cup." Thus Ximenez gives them, and adds that forms of speech with *rax* signify things of beauty, fit for kings and lords, as are brightly colored cups and dishes.

Rax is the name of the colors blue and green, which it is said by many writers, cannot be distinguished apart by these Indians; or at least that they have no word to express the difference. *Rax*, by extension, says Ximenez (*Gramatica de la Lengua Quiche*, p. 17), means strong, rough, violent, etc. Coming immediately after the names "Soul of the Lake," "Soul of the Sea," it is possible that the "blue plate" is the azure surface of the tropical sea.

In the second paragraph I have quoted the narrator introduces us to "the Ancestress (*iyom*), the ancestor (*mamom*), by name Xpiyacoc, Xmucane." These were prominent figures in Kiche mythology; they were the embodiments of the paternal and maternal powers of organic life; they were invoked elsewhere in the Popol Vuh to favor the germination of seeds (p. 20), and the creation of mankind; they are addressed as "ancestress of the sun, ancestress of the light" (p. 18). The old man, Xpiyacoc, is spoken of as the master of divination by the *tzite*, or sacred beans (p. 23); the old woman, Xmucane, as she who could forecast days and seasons (*ahgih*); they were the parents of those mighty ones "whose name was Ahpu," masters of magic (p. 69). From this ancient couple, Ximenez tells us the native magicians and medicine men of his day claimed to draw their inspiration, and they were especially consulted touching the birth of infants, in which they were still called upon to assist in spite of the efforts of the padres. It is clear throughout that they represented mainly the peculiar functions of the two sexes.

Their names perhaps belonged to an archaic dialect and the Kiches either could not or would not explain them. Brasseur does not offer any etymology, and all that Ximenez says is that Xmucane means *tomb* or *grave* (entierro o fosa), deriving it from the verb *tin muk*, I bury.

In most or all of the languages of this stock the root *muk* or *muc* means to cover or cover up (*encubrir*). In Maya the passive form of the verbal noun is *mucaan*, of which the *Diccionario de Motul** gives the translation "cosa que esta encubierta ò enterrada," the second meaning arising naturally from the custom of covering the dead body with earth, and indicated that the mortuary rites among them were by means of interment; as, indeed, we are definitely informed by Bishop Landa.† The feminine prefix and the terminal euphonic *e* give precisely *X-mucaan-e*, meaning "She who is covered up," or buried.

But while etymologically satisfactory, the appropriateness of this deri-

* The *Diccionario de Motul* is the most complete dictionary of the Maya ever made. It dates from about 1590 and has its name from the town of Motul, Yucatan, where it was written. The author is unknown. Only two copies of it are in existence, one, very carefully made, with numerous notes, by Dr. Berendt, is in my possession. It is a thick 4to of 1500 pages.

† *Relacion de las Cosas de Yucatan*, § XXXIII.

vation is not at once apparent. Can it have reference to the seed covered by the soil, the child buried in the womb, the egg hidden in the nest, etc., and thus typify one of the principles or phases of reproduction? For there is no doubt, but that it is in the category of divinities presiding over reproduction this deity belongs.

Both names may be interpreted with appropriateness to the sphere and functions of their supposed powers, from radicals common to the Mayá and Kiche dialects. Xmucane may be composed of the feminine prefix *x* (the same in sound and meaning as the English pronominal adjective *she* in such terms as *she bear, she cat*): and *mukanïl*, vigor, force, power, (fortaleça, fuerza, poder, Brasseur, *Vocabulaire Maya, Francais et Español*, on the authority of Ruz and Beltran).

Xpiyacoc is not so easy of solution, but I believe it to be a derivative from the root *xib*, the male, whence *xipbil*, masculinity, and especially the *membrum virile* (Pio Perez, *Diccionario Maya*); and *oc* or *ococ*, to enter, to accouple in the act of generation (entrar, juntarse el macho con la hembra, Brasseur, *Vocabulaire Maya*, s. v. *oc*).*

We can readily see with these meanings hidden in them, the subtler sense of which the natives had probably lost, that they would be difficult of satisfactory explanation to the missionaries, and that they would be left by them as proper names of undetermined origin.

The second fragment of Kiche mythology which I shall analyze is one that relates to the gods of the storm. These are introduced as the three manifestations of Qux-cha, the Soul of the Sky, and collectively "their name is Hurakan:"

> "Cakulha Hurakan is the first; Chipi-cakulha is the second; "the third is Raxa-cakulha; and these three are the Soul of "the Sky" (p. 8).

Elsewhere we read:

> "Speak therefore our name, honor your mother, your "father; call ye upon Hurakan, Chipi-cakulha, Raxa-cakulha, "Soul of the Earth, Soul of the Sky, Creator, Maker, Her who "brings forth, Him who begets; speak, call upon us, salute "us." (p. 14).

Cakulha (Cakchiquel, *cokolaha'y*) is the ordinary word for the lightning;

*This Vocabulary collected by the Abbé Brasseur (de Bourbourg) was published in the second volume of the reports of the *Mission Scientifique au Mexique et dans l'Amérique Centrale, Paris*, 1870. I regret to say that like all of his linguistic work, it must be followed with great caution. He has inserted in it many words and forms which are not Maya at all, and the derivations he gives and suggests are generally the merest guesses, based on the slenderest analogies of sound. In fact, a careful student of the tongue should not accept any Maya word on the sole authority of Brasseur's work.

Raxa-cakulha, translated by Brasseur "la foudre qui frappe subitement" is rendered by Coto as "the flash of the lightning" (*el resplandor del rayo*); Chipi-cakulha is stated by Brasseur to mean "le sillonnement de l'eclair;" *ghip* is used to designate the latest, youngest or least of children, fingers, etc.

There remains the name Hurakan and it is confessedly difficult. Brasseur says that no explanation of it can be found in the Kiche or Cakchiqùel dictionaries and that it must have been brought from the Antilles where it was the name applied to the terrible tornado of the West Indian latitudes, and, borrowed from the Haytians by the early navigators, has under the forms *ouragan, huracan, hurricane,* passed into European languages. In default of any other probable origin such for a long time was my own opinion, and it is indeed difficult to allow the probability that in Hayti and Guatemala the same word should be applied to the same conception, and this one of such magnitude and impressiveness, and that there should be no historic connection between the two. However that may be, I am now convinced that the word Huracan belongs in its etymology to the Maya group of dialects, and must be analyzed by them.

One such etymology is indeed offered by Ximenez, but an absurd one. He supposed the word was compounded of *hun,* one *ru* his, and *rakan* foot, and translates it "*de un pie.*" This has very properly been rejected.

On collating the proper names in the Popol Vuh there are several of them which are evidently analogical to Hurakan. Thus we have *Cabrakan,* who is represented as the god of the earthquake, he who shakes the solid earth in his might and topples over the lofty mountains. To this day his name is the common word for earthquake in these dialects. Again, one of the titles of Xmucane is *Chirakan Xmucane* (p. 22).

The terminal *rakan* in these names is a word used to express greatness in size, height or bigness. Many examples are found in Coto's *Vocabulario.* He says

"**Larga cosa:** Lo ordinario es poner *rakan* para significar la largura "de palo, cordel, etc.: para decir, larga caballera trae aquella muger, "dicen: *nahtik rakan ru vi lae ixok.*"

For a person tall in stature he gives the expression *togam rakan:* for large in body (grande del cuerpo) the Cakchiqùel is *naht rakan.* But the most appropriate entry in this connection is that in which he gives us the Cakchiqùel of *giant:*

"**Gigante:** *hu rapah rakan chi vinak, hu chogah rakan chi vinak;* este "nombre se usa de todo animal que en su specie es mas alto que los "otros. Meo. P^e^ Saz, serm. de circumsciss. dice del Gigante Golias: "*tugotic rogoric rakan chiachi* Gigante *Golias.*"

Here we find the exact combination, *Hu-rakan,* used in the signification of the greatest of a kind, gigantic, colossal. Among the Northern Indians the notion prevailed that each species of animal included one enormous one, much larger than the others, to whom others were subject, and which

was the one who often appeared to the Indian in his "medicine dreams." This was apparently, from the expression of Father Coto, also the opinion of the Guatemalan tribes, and to this mythical giant specimen of the race they applied the term *hu-rapa-rakan*, "the one exceeding great in size." This idea of strength and might is of course very appropriate to the deity who presides over the appalling forces of the tropical thunder storm, who flashes the lightning and hurls the thunderbolt.

It is also germane to the conception of the earthquake god. The first syllable, *cab*, means twice or two or second; and apparently has reference to *hun*, one or first, in *hurakan*. As the thunderstorm was the most terrifying display of power, so next in order came the earthquake. Were it allowable to alter the initial *c* into the guttural $\frac{c}{c'}$, giving us $\frac{c}{c}$ *ab rakan*, then the name would mean "the mighty hand."

The name *Chirakan* as applied to Xmucane may have many meanings; *chi* in all these dialects means primarily *mouth;* but it has a vast number of secondary meanings, as in all languages. Thus, according to Coto, it is currently used to designate the mouth of a jar, the crater of a volcano, the eye of a needle, the door of a house, a window, a gate to a field, in fact, almost any opening whatever. I suspect that as here used as part of the name of the mythical mother of the race and the representation of the female principle, it is to be understood as referring to the vaginal cleft, the *ostium vaginæ*, from which, as from an immeasurable *vagina gentium*, all animate life was believed to have drawn its existence.

The same syllable occurs as a prefix in another female name, *Chimalmat*, the mother of Cabrakan (p. 34). This name may, with an effort, be derived from Cakchiquel roots, but as it is absolutely identical with one of a goddess well known in Aztec mythology, I shall consider it later. Suffice it to say here that the verb *malmot*, according to Varea, means to enter suddenly, to appear unexpectedly.

If the derivation of Hurakan here presented is correct, we can hardly refuse to explain the word as it occurs elsewhere with the same meaning as an evidence of the early influence of the Maya race on other tribes. It would appear to have been through the Caribs that it was carried to the West India islands where it was first heard of by the European navigators. Thus the *Dictionaire Galibi* (Paris, 1743) gives for "diable," *iroucan, jeroucan, hyorokan*, precisely as Coto gives the Cakchiquel equivalent of "diablo" as *hurakan*. This god was said by the Caribs to have torn the islands of the West Indian archipelago from the mainland and to have heaped up the sand hills and bluffs along the shores.* As an associate or "captain" of the hurricane, they spoke of a huge bird who makes the winds, by name *Savacon*, in the middle syllable of which it is possible we may recognize the bird *vaku*, which, as we shall shortly see, the Kiches spoke of as the messenger of Hurakan.

* De la Borde, *Relation de l'origine, etc., des Caraibes*, p. 7. (Paris, 1674).

I shall add here an invocation to Hurakan which is one of the finest in the Popol Vuh :

1. Acarroc, Atoob u gih, at Hurakan, at u Qux cah, uleu !
   Hail, beauty of the day, thou Hurakan, thou (its) Heart, the Sky, the Earth !
2. At yaol rech ganal-raxal, at pu yaol mial, qahol !
   Thou giver (of) our prosperity, thou, and giver (of) daughters, sons !
3. Ch'a tziloh, ch'a maquih uloc a raxal, a ganal :
   Make firm, extend hither thy glory, thy greatness :
4. Ch'a yatah u qazsic, vinakiric v'al nu qahol :
   Give their life, (their) increase to my descendants :
5. Chi pog-tah, chi vinakir-tah, tzukul ave, cool ave,
   That they may beget, may increase nurses for thee, guards for thee,
6. Ziquiy ave pa be, pa hoc, pa beya, pa xivan, xe che, xe caam.
   Who shall invoke thee in the roads, in the paths, in the water ways, in the gorges, under the trees, under the bushes.
7. Ch'a yaa qui mial, qui qahol ;
   Give to them daughters, to them sons ;
8. Ma-ta-habi il-tzap, yanquexo ;
   Let there not be disgrace, misfortune ;
9. Ma-ta ch'oc qaxtokonel chiquih, chi qui vach.
   That not comes the deceiver behind them, before their face.
10. M'e pahic, m'e zokotahic ; m'e hoxonic, m'e gatonic.
    May they not fall, may they not stumble ; may they not hurt their feet, may they not suffer pain ;
11. M'e kahic r'equem be, r'ahzic be.
    May they not fall in the low road, in the high road.
12. Ma-ta-habi pak, toxcom chiquih, chi qui vach.
    Let there not be a stumbling block, a scourge behind, before their face.
13. Que a yatah pa raxa be, pa raxa hoc ;
    Give them (to be) in a green road, in a green path ;
14. Ma-ta-habi qu'il, qui tzap a cuil, av'itzmal.
    Let there not be to them evil, to them misfortune (from) thy locks, thy hair.
15. Utz-tah qui qoheic tzukul ave, cool ave ch'a chi, ch'a vach.
    Fortunate to them (be) existence, nurses thine, guardians thine, be-before thy mouth, before thy face,
16. At u Qux cah, at u Qux uleu, at pizóm Gagal ! at puch Tohil !
    Thou its heart the sky, thou its heart the earth, thou veiled Majesty ! thou and Tohil.
17. At puch Tohil, Avilix, Hacavitz, pam cah, u pam uleu, cah tzak, cah xucut.
    Thou and Tohil, Avilix, Hacavitz, body (of the) sky, its body the earth (with its) four sides, four corners.

18. Xa-ta zak, xa-ta amag, u pam ch'a chi ch'a vach, at Qabauil!
So long as light, so long as time, (be) its body before thy mouth before thy face, thou God!

1. *Acarroc* is an interjection of admiration or awe. *Atooh* is the plural form with intensive signification of *ato*, beautiful, fine, good.

2. *Ganal-raxal*, literally "yellowness, greenness." I shall refer to this combination in a later paragraph.

At pu, thou and, read "and thou;" the copulative conjunction in Kiche, like the Latin *que*, often follows the first word of the connected clause.

3. *Ch'a tziloh;* both Ximenez and Brasseur translate this "turn thee;" but this requires *tzeloh*, and is less germane to the sense of the passage. The color terms, *rax, gan* again appear in their metaphorical senses of prosperity.

4. *Vinakiric*, form the root *vin*, to increase, gain.

9. *Qaxtokonel*, the liar; *qaxtog* is the usual word for *demonio, diablo*, in the religious language.

10. *M'e hoxonic, m'e gatonic;* Ximenez, and following him Brasseur, translate this, "May they not fornicate, may they not be brought before the judge;" but the meanings in the text are also given to these words in Ximenez' own *Tesoro de las tres Lenguas*, and are much more likely to have been the original ones.

14. *A cuil av'itzmal;* thy locks, thy hair. This probably has reference to a myth or superstition about the storm god's strength, lying, like Samson, in his hair.

16. *Pizom Gagal;* Ximenez translates "envoltorio de gloria."

17. *At puch Tohil;* read: "And thou (also) O Tohil, etc. *Pum*, from *pa*, in, means "the contents of anything hollow," hence entrails, and generally belly. Ximenez translates it here *vientre*, but "body" is probably nearer the right sense, as it stands in antithesis to *heart* in the previous line.

There is another invocation in the Popol Vuh containing some other names of deity, a literal translation of which I shall give, after Brasseur:

"Hail! O Creator, Maker! Who sees and hears us! Do "not leave us; do not desert us. O Qabauil, in the sky, on "earth, Soul of the Sky, Soul of the Earth. Give us children, "posterity [as long as] the sun goes, and the light. Let the "seed grow, the light come. Many green paths, green roads, "give us; in peace, in white peace, be the tribe; in welfare, "in white welfare, be the tribe; give us then happy life and "existence, O Hurakan, Chipi-cakulha, Raxa-cakulha, Chipi-"nanauac, Raxa-nanauac, Voc, Hunahpu, Tepeu, Gucumatz, "Alom, Qaholom, Xpiyacoc, Xmucane, Grandmother of the

"Sun, Grandmother of Light; let the seed grow, the light "come." p. 210.

Such was the prayer, which according to Kiche traditions, their early ancestors addressed to the divinities, in those far-off years when they dwelt in the distant Orient, in the fertile land of Paxil and Cayala, before they had yet gone to Tulan to receive the tribal and family gods which they adored in later days.

There is no trace of Christian doctrine in these names; clearly they are all handed down from a generation who knew nothing of missionaries and their teachings. Most of them I have already analyzed, and I shall now take up the remainder.

The term *Qabauil* is in Kiche the generic word for divinity. Thus we find in the Popol Vuh such expressions as: *Xavi e qabauil*, truly they were gods (p. 34); *are u bi ri qabauil*, this is the name of God (p. 8). It is from the root *qab*, for the correct signification of which we must perhaps go to the Maya, where it means to create, to make out of nothing. (*Chab*, crear, sacar de la nada, Pio Perez, *Diccionario de la Lengua Maya*.) The word had so many heathenish associations that the Franciscan missionaries dropped it, and substituted the Spanish *Dios*, from which they formed derivatives according to the rules of native grammar. Thus Coto translates *divina cosa* by *diosil* and adds: "antiguamente decian *gabovi al*, de *gabo-* "*vil*, nombre del dios que adoraban." He gives other derivatives, also:

"**Idolatrar:** *qui gabovilan;* idolo, *gabovil.* * * Lo mesmo dicen de las "pinturas que antiguamente hacian; *gabul* vel *gabuil*. *Gabuilhay*, casa "de idolatria; *gabuil chahal*, el sacerdote, vel guarda de los idolos."

Father Varea seems to derive *gabuyl* from *g'ibak*, to paint:

"**Gabuyl:** estatua o ydolo propriamente de bulto ò pintada la figura ò "ymagen de lo q adoraban los gentiles."

The Dominican missionaries, however, in their writings in the native language adopted *gabuyl* as the correct rendering of *Dios*, God, and this difference of opinion between them and the Franciscans led to some acrimonious linguistic polemics.

Father Hieronimo Roman, from the narratives at his command, states that the name was that of a definite being, the supreme God of the natives of Guatemala.*

The names *Chipi-nanauac*, *Raxa-nanauac*, are supposed by Brasseur to refer to the Aztec divinity Nanahuatl. They are, however, easily explicable by the Kiche itself. They are derived from the root *nao*, to know, understand, absolute form, *qui nao*, which, says Coto, "signifies everything, which is known or learned by custom or experience;" *naoh*, is understanding, reason, intellectual power; *ahnaoh* is the Cakchiquel for *artium magister*. It also applies to understanding the thoughts of another;

* "El Dios que tenian por supremo, como nosotros, llamavanlo en la Provincia de Guatemala Cabouil." *Republicas del Mundo, Tercera Parte, De la Republica de las Indias Occidentales.* Lib. II, Cap. XV.

Padre nonohel ka zih, the Father understood our story. In a derived application it signified that mysterious and supernal knowledge which the magician and diviner possess, and which, in its highest form, is the peculiar attribute of divinity. In this sense it is synonymous with *puz*, which I have already discussed, and both are given by Coto as the words for magic and necromancy. Both are also employed together in various passages of the Popol Vuh. Thus it is said (p. 10) that in the beginning the mountains and the valleys, the cypresses and the pines were created instaneously by miracle, by magic, *xaki naual, xaki puz ;* so it is said of the formation of the first men that it was by enchantment, by sorcery—*xa puz, xa naual qui tzakic* (p. 198). The expression *nanauac*, therefore has no reference to Aztec myth but to the supernatural power of Divinity, and probably especially to the psychical and intellectual manifestation of the divine energy.

The radical of these comprehensive words is *na*, to feel, to preceive (sentir, advertir, Varea). The reduplication appears in the forms *ta nana*, look, *nanoh*, appointed, designated, and is common in the Maya derivatives from this root, as appears, for instance, in the following entry from the *Diccionario de Motul* :

"**Nanaol:** considerar, contemplar, entender y arbitrar."

The following are definitions from Varea :—

"**Naoh:** el sentido, el uso, la experiencia, el arte, la industria, el buen "ingenio en los hombres, y el instinto natural en los brutos.

"**Naohih:** hacer algo los animales con buen instinto : y tambien hazer "el hombre algo con prudencia, arte, buen uso o tiento con entendi- "miento.

"**Naohticah:** enseñar ò doctrinar costumbres, artes, letras, cosas "buenas ô malas.

"**Nanoxin:** tener muy de memoria algo.

"**Naval:** creyan que avia cosa viva dentro del arbol, piedra ò monte que "hablaba, llamaba [hence *naval che*, spirit of the tree, *naval abah* spirit "of the stone].

"**Navalih:** hazer milagros de echizeros encantos.

"**Puz Naval:** era una manera de nigromancia ô magica que usaban los "yndios tranformandose en globos de fuego y en aguila y otros animales "que yban por el ayre."

The process of thought seen in these derivatives is interesting to note. From the simple use of the senses (*na*), come experience, knowledge, ability, skill (*naoh*), he who has these to a great degree can do more than others, he can work wonders (*navalih*) ; he can understand the voices of nature which speak in the babbling brook, the moaning of the wind, the crackling fire, the rattling stones (*naval*) ; and in his highest attainments may transform himself into any other form of existence (*puz naval*).

Such is the testimony which these rude natives bear through the witness of their language to the source and power of knowledge ; and such

was the impression it made upon their untutored minds that even to this day, after more than three hundred years of Christian teaching, it is not the mild Judean Virgin, nor the severe Christian God who is their highest deity, but it is the wise Naoh, the Spirit of Knowledge, the Genius of Reason, who in secret still receives their prayers as the greatest of all the gods. They have also other divinities whose worship has constantly been retained in spite of all the efforts of the missionaries.*

The word *naual* appears also to have been used to express that intellectual communion with the lower animals which the priests often claimed, to the effect that they could understand the songs of birds, etc. Coto remarks that the natives had the superstition that twins are by birth *naual* to rats, "that is, that they have the characteristics of rats, that they will gnaw the clothing of those who irritate them," etc.†

The name *Voc* is that of a species of bird (Cakchiquel *Vaku*). Coto describes it as having green plumage, and a very large and curved bill, apparently a kind of parrot. Elsewhere in the myth (p. 70) it is said to be the messenger of Hurakan, resting neither in the heaven nor in the underworld, but in a moment flying to the sky, to Hurakan who dwells there.

The tribal gods are first mentioned in the last part of the Popol Vuh, and they are said to have been given the people in "Tulan Zuiva," a town where they went to receive them (p. 215). The Tecpan-Atitlan records state that these gods were first given "in Tullan in Xibalbay," one of the four places of the name of Tulan, which that ancient and interesting legend refers to. The names of these gods were Tohil, Avilix, Hacavitz, and Nicahtagah.

*"Die bedeutendsten Gottheiten der Indianer von Istlávacan, denen sie noch bis zur Stunde zu gewissen Zeiten im Geheimen, im düsteren Urforst opfern und zu deren Ehren sie zuweilen sogar Feste begehen, heissen: Noj, der Genius der Vernunft, Ajmak, der Genius der Gesundheit, Ik, der Mond, Kanil, der Genius der Aussaat und Juiup, der Gott der Erde, welcher unter den Indianern das böse Princip vorstellt, im Gegensatze zu Kij, dem Gott des Lichtes, dem guten Princip." Dr. K. Scherzer, *Die Indianer von Santa Catalina Istlávacan*, p. 12. These Indians are said to be the pure-blooded descendants of the ancient Kiches. Of these names Noh, Naoh, is explained above; Ahmak is the name of a day in the calendar, meaning uncertain; Ik, the moon; Kanil, yellow, refers to the color of maize when ripe and hence the harvest; Juiup, probably *uliu* the earth; ᵡIj — g'ih, sun, day, light, &c. Dr. Scherzer says that they still look upon mountains, trees, etc., as habitations of particular gods. He also adds that to this day among them every child at his birth is named after and put under the protection of some species of animal; and this animal is called his *nagual* or *nawal*. In one curious episode in the Popol Vuh where the people sent forth to the bath two beautiful maidens in order to seduce the god Tohil, it is related that what they wished was that these virgins should be deflowered, *qui naual Tohil*, by the mystic power of Tohil (p. 268). The verb *noh* has the signification to fill, and hence to impregnate, fecundate, and is often so used in the Popol Vuh (*e. g.* p. 12). This gives occasion for a combination of genesiac rites and myths with the worship of Reason.

†That particular form of superstition called *Nagualism*, which still prevails among some Central American nations, derives its name from this root. It has been described by the Abbé Brasseur in his *Voyage sur l'Isthme de Tehuantepec*, Paris, 1861, and in the *Bull. de la Soc. de Geographie, Paris*, Ser i, xiii.

Tohil is supposed by Ximenez to be the same as Toh, which is the 9th day of the calendar, and is the sign of rain. Brasseur thinks the orthography should be *Tohohil*, which is from a verb *tohoh*, meaning to sound, resound, make a loud noise, and has relation to the thunder, the legend saying that Tohil produced fire for men by striking his shoe. This derivation he bases on a passage in the *Records from Tecpan Atitlan* where there is apparent reference to this divinity, with a derivation from *tohoh*. It is as follows: After an important battle in the early days of their history, the tribes gathered together on a great mountain, Tepeu Oloman, and there consulted as to measures of safety. The *Records* read:

"Tok xka qutubeh qa ki, ha xa colovi avi, xoh cha chi re
"When we asked one another whence our comfort, to us then spoke
"Qeche vinak: Xaqui tohoh quihilil xibe chi cah, xa chi cah xhe
"the Kiche men: It has sounded loudly above in the sky, from in the sky
"nu colo vivi Xcha quere qa xubinaah vi
"our comfort will be. Thus was said (and thus) came the name
"Tohohil ri.
"*the Loud-Sounding* to them.

The derivations of a number of other tribal names are given in the same passage, but it is probable, like many in other ancient records, the derivations were altogether an afterthought, and were attached at a late date to the ancient legend.

It is impossible, however, to obtain *Tohil* from *tohoh* without straining the rules of derivation in their language. On the other hand, it may be very correctly explained as the determinative form of the verb *toh*, a root common to this whole linguistic family. The primitive meaning of this monosyllable seems to have been to give what is due, to pay what is owed. In one sense, we do this in paying debts, in another in punishing an enemy, in yet another in telling the truth where it is properly expected of us. The man who does all this does right, he is just, he causes strife to cease, and pacifies his neighbors; as such, he is a good, sound, healthy man, free from infirmities. That this was the course of thought in the development of this root will be clearly seen by the following extracts from that admirable monument of linguistic industry, the *Diccionario de Motul*:

"**Toh:** v. pagar deudas.
"**Toh:** s. la verdad; lo que es verdad ô verdadero.
"**Toh:** s. venganza.
"**Tohil:** derechura, ô lo derecho y justicia.
"**Tohalol:** estar bueno ô consolado.
"**Tohancilol:** estar bueno de salud; descuidarse, asegurarse.
"**Tohcinahol:** consolar ô quietar y pacificar: y asegurar deuda.
"**Tohol:** sano, sin enfermedad.

Such is the group of ideas which were associated in the native mind with the name and character of *Tohil*. He was the Just one, he distributed equitably to men their rewards and their punishments, he was the Com-

forter, the Avenger, who protected and consoled. He it was, according to the legend, who gave the inestimable blessing of fire to men, obtaining it by striking his shoe (p. 218). As the deity who was looked up to by the Kiche as their benevolent guide, teacher and guardian, the native writer identified him with the Mexican Quetzalcoatl, the mythical founder of the Nahuatl civilization (p. 246); but this must not be taken too literally, as the assertion itself only shows the general similarity of character between these two deities, and is far from being sufficient to prove their historical identity.

No derivations whatever have been suggested for Avilix and Hacavitz. The latter, I think, is a compound of *hak*, *haka*, to open, disclose, reveal, and also to listen to; and *vix*, which means primarily a root, but which in a metaphorical sense meant ancestors; as Varea says:

"**Vix:** la rayz de todo arbol. * * A sus padres llaman tambien los "Indios, *ru vixil;* dicenlo tambien de nuestros primeros Padres, Adan "y Eva."

The sense would be, He who listened to our Ancestors.

The mythical ancestors of the royal Cakchiquel family of the Xahila were $\overset{c}{c}\,a\,\overset{c}{c}$*avitz* and *Zactecauh.** If, as seems probable, the former is a compound of $\overset{c}{c}\,a\,\overset{c}{c}$ *al*, royal, *vix*, root stem, stirps, a very natural meaning appears in the name; $\overset{c}{c}\,a\,\overset{c}{c}$ *al* itself, is, according to the *Calepino* of Varea, a derivative from $\overset{c}{c}\,a\,\overset{c}{c}$ fire or flame, through the same easy analogy which leads us to associate brightness with glory and greatness.

I have not found a clear derivation for Avilix; but it is probably from the verb *ylin*, future *zavilah*, to protect, care for.

The compound Nicah-tagah is plain enough—*nigah*, the middle, *tagah*, a plain, a sea-coast, a town. This is given by Brasseur. But one point escaped his notice, which throws another light on the mythological significance of this deity. By a transfer common in most languages, the word for middle was also applied to the organs of generation (las verguenzas de hombre ô muger, Varea, *Calepino*). This divinity holds an inferior place, and indeed is, I believe, not again mentioned in the legend.

I now pass to the curious episode of the descent of the hero-god or gods, Xbalanque, into the underworld, Xibalba, his victory over the inhabitants, and triumphant return to the realm of light. The exploits of this demigod are the principal theme of the mythological portion of the Popol Vuh.

It was the vague similarity of this myth to the narrative of the descent of Christ into Hell, and His ascent into Heaven, to which we owe the earliest reference to these religious beliefs of the Guatemalan tribes; and it is a gratifying proof of their genuine antiquity that we have this reference. Our authority is the excellent Bishop of Chiapas, Bartolome de

* *Records from Tecpan-Atitlan*, written by Don Francisco Ernantez Arana Xahila, 1573. MSS. in Cakchiquel in my possession.

las Casas, and after him Alonzo Fernandez, and later writers. Their account reads:

"Dicen fué este Dios [Exbalanquen] à hazer guerra al infierno, y peleó "con grande numero de demonios. Vencío los, y prendio al Rey del "infierno, y à otros muchos de los suyos, y bolvio al mundo vitorioso. "Llegando cerca de la tierra, el Rey del infierno pidio que no le sacasse "de su lugar. Exbalaquen (que asi se llaman este gran Dios) le dio un "empellon, y le bolvio á su proprio Reyno, diciendole; Sea tuyo todo "lo malo, sucio y feo. Viniendo vencedor, no le quisieron recibir los de "Guatemala y Chiapa con la honra que era razon; y por lo cual se fue "à otra Provincia, adonde fué con grandes ceremonias recibido. Re- "fieron que deste vencedor del diablo tuvo principio el sacrificar "hombres."*

Las Casas adds that Xbalanque was born in Utlatlan, which we may construe as merely a claim made by the Kiches to the birthplace of the hero god, which doubtless would have been contested by their neighbors, for there is evidence that we have here to do with a myth which was a common property of the Maya stock. As related in the Popol Vuh where it is told in a confused manner, and at wearisome length, it is briefly as follows:

The divine pair Xpiyacoc and Xmucane had as sons Hunhun-Ahpu and Vukub-Hun-Ahpu (Each-one-a-Magician and Seven-times-a-Magician). They were invited to visit Xibalba, the Underworld, by its lords, Hun-Came and Vukub-Came (One-Death and Seven-Deaths), and accepting the invitation, were treacherously murdered. The head of Hunhun-Ahpu was cut off and suspended on a tree. A maiden, by name Xquiq, Blood, passed that way, and looking at the tree, longed for its fruit; then the head of Hunhun-Ahpu cast forth spittle into the outstretched palm of the maiden, and forthwith she became pregnant. Angered at her condition, her father set about to slay her, but she escaped to the upper world and there brought forth the twins Hun-Ahpu and Xbalanque. They grew in strength, and performed various deeds of prowess, which are related at length in the Popol Vuh, and were at last invited by the lords of the Underworld to visit them. It was the intention of the rulers of this dark land that the youths should meet the same fate as their father and uncle. But prepared by warnings, and skilled in magic power, Xbalanque and his brother foiled the murderous designs of the lords of Xibalba; pretending to be burned, and their ashes cast into the river, they rose from its waves unharmed, and by a stratagem slew Hun-Came and Vucub-Came. Then the inhabitants of the Underworld were terrified and fled, and Hun-Ahpu and Xblanque released the prisoners and restored to life those who had been slain. The latter rose to the sky to become its countless stars, while

* Las Casas, *Historia Apologetica de las Indias Occidentales*, cap cxxiv (Madrid edition): P. F. Alonzo Fernandez, *Historia Ecclesiastica de Nvestros Tiempos*, p. 137. (Toledo, 1611).

Hun-hun-Ahpu and Vucub-Hun-Ahpu ascended to dwell the one in the sun, the other in the moon.

The portion of the legend which narrates the return of Xbalanque to the upper world, and what befell him there, as referred to in the myth preserved by Las Casas, is not preserved in the Popol Vuh.

The faint resemblance which the early missionaries noticed in this religious tradition to that of Christ would not lead any one who has at all closely studied mythology to assume that this is an echo of Christian teachings. Both in America and the Orient the myths of the hero god, born of a virgin, and that of the descent into Hades, are among the most common. Their explanation rests on the universality and prominence of the processes of nature which are typified under these narratives. It is unscientific to attempt to derive one from the other, and it is not less so to endeavor to invest them with the character of history, as has been done in this instance by the Abbé Brasseur (de Bourbourg), and various other writers.

The Abbé maintained that Xibalba was the name of an ancient State in the valley of the Usumasinta in Tabasco, the capital of which was Palenque.* He inclined to the belief that the original form was *tzibalba*, which would mean *painted mole*, in the Tzendal dialect, and might have reference to a custom of painting the face. This far-fetched derivation is wholly unnecessary. The word Xibalba, Cakchiquel Xibalbay, Maya Xibalba, Xabalba or Xubalba (all found in the *Diccionario de Motul*, MSS.), was the common term throughout the Maya stock of languages to denote the abode of the spirits of the dead, or Hades, which with them was held to be under the surface of the earth, and not, as the Mexicans often supposed, in the far north. Hence the Cakchiquels used as synonymous with it the expression "the centre or heart of the earth."

{ *ch'u qux uleu*
{ in its heart the earth. (Coto *Dicc.* s. v.).

Coto adds that the ancient meaning of the word was a ghost or vision of a departed spirit—"antiguamente este nombre *Xibalbay* significaba el de-"monio, vel los diffuntos ô visiones que se les aperescian, y asi decian, y "aun algunos ay que lo dicen oy, *xuqutzii xibalbay ri* $\frac{c}{c}$ *etzam chi nu vach*, "se me aparec'ó el diffunto."

After the conquest the word was and is in common use in Guatemala dialects to mean *hell*, and in Maya for *the devil*. Cogolludo states that it was the original Maya term for the Evil Spirit, and that it means "He who disappears, or vanishes."† He evidently derived it from the Maya verb *xibil*, and I believe this derivation is correct; but the signification he

* *Dissertation sur les Mythes de l'Antiquité Americaine*, § viii (Paris, 1861); see also his note to the *Popol Vuh*, p. 70.

† "El Demonio se llamaba *Xibilha*, que quiere decir el que se desparece ó desbanece." *Historia de Yucathan*, Lib. iv, cap. vii. Cogolludo had lived in Yucatan twenty-one years when he was making the final revision of his History, and was moderately well acquainted with the Maya tongue.

given is not complete. I quote from the *Diccionario de Motul*, MSS. the entry relating to this word:

"**Xibil,** *xibi, xibic:* cundir como gota de aceita; esparcirse la comida en "la digestion, y deshacerse la sal, nieve ô yelo, humo ô niebla.

"*item:* desparecerse una vision ô fantasma.

"*item:* temblar de miedo y espantarse.

"*item:* quitarse el doler y la calentura."

In the Cakchiquel we have the same word *xibih*, to frighten, to terrify, from which are derived the instrumental form *xibibeh*, the verbal noun *xibibal*, that which causes terror (*e. g.*, *xibibal gel*, lit. "that which frightens birds," *i. e.* the scarecrow set up in the cornfields, Varea), etc. This is the secondary meaning of the root, and is the only one which seems to have survived in the Guatemala dialects. The original signification of the word was undoubtedly "to melt, dissolve," thus disappear, and in this sense it was applied to the act of death, the disappearance of man from this mortal life.

It is most interesting in this instance to note how the mental processes of these secluded and semi-barbarous tribes led them to precisely the same association of ideas which our greatest dramatist expresses in the opening lines of Hamlet's famous soliloquy:

> "O, that this too too solid flesh would melt,
> Thaw, and resolve itself into a dew;"

And which Cicero records in the expression *dissolutio naturæ* in the sense of death (*De Legibus I. ii. et al.*).

The natural terror and fright with which death and ghosts are everywhere regarded, and especially, as Landa remarks, by this people,* explains how this secondary meaning became predominant in the word. The termination *ba* means in the Guatemala dialects, where, whence, whither, *bey*, a path or road; *Xibilbay* thus signifies, in its locative sense, the place where they (*i. e.* the dead) disappear, the Hades, the Invisible Realm, which, as I have above appointed out, was supposed to be under the ground.

It was a common belief among many tribes in America, as I have elsewhere shown,† that their earliest ancestors emerged from a world which underlies this one on which we live, and in ancient Cakchiquel legend, the same or a similar notion seems to have prevailed. At least, such I take to be the sense of a passage in the earlier pages of the *Memorial de Tecpan-Atitlan*, which I shall transcribe from the copy in my possession, with the translation of the Abbé Brasseur, which, however, by his own statement, cannot be depended upon as accurate.

"Tan qa talax ri Chay Abah, rumah raxa Xibalbay, gana Xibalbay tan "qa ti qak vinak ruma qakol bitol; tzukul richin ri Chay Abah ok xqak "ri vinak pan pokon qa xutzin vinak.

* *Relacion de las Cosas de Yucatan*, § xxxiii.

† *The Myths of the New World*, p. 244 (second edition).

"Le Chay Abah est sorti de Xibalbay, du riche et puissant Xibalbay.
"L'homme est l'euvre de son createur et formateur, et celui qui sou-
"tiens le Createur c'est ce Chay Abah. Or il forma l'homme et le per-
"fectionna dans le douleur."

The name of the hero-god Xbalanque is explained by the Abbé Brasseur to be compounded of the diminutive prefix *x*, *balam* a tiger and the plural termination *que*.* Like so many of the derivations offered with great confidence by the worthy Abbé, this one is quite incorrect. There is no plural termination *que*, neither in the Kiche nor in any related dialect; and the signification "tiger" (jaguar, *Felix unca* Lin. in Mexican *ocelotl*), which he assigns to the word *balam* is only one of several which belongs to it.

The name is compounded of the prefix, either feminine or diminutive *x*; *balam*, or, as given by Guzman, *balan*;† and *queh*, deer. This is the composition given by Ximenez, who translates it literally as "diminutivo de tigre y venado."‡

From analogies easy to perceive, the name *balam*, was also applied to a class of warriors; to a congregation of priests or diviners; and to one of the inferior orders of deities. In composition it was applied to a spotted butterfly, as it is in our tongue to the "tiger-lily;" to the king-bee, to certain rapacious birds of prey, etc.

I quote the following entries in the manuscripts before me:

"**Balam:** tigre.
"**Balam malax:** mariposa grande.

GUZMAN, *Compendio de Nombres.*

"**Balamil cab:** el rey de abejas.
"**Balamil cah:** los sacerdotes del pueblo, cacique y regidores, que "con su fortaleza lo guardan.
"**Balamil chich:** aves de rapina.

"*Diccionario de Motul.*

"**Balam:** el tigre, *Zakbalam*, tigre pequeño de su natureleza; $\overset{c}{c}$*ana balam*, "el grande.

"**Balam:** tambien sig^{a} un signo de los Indios. *Maceval* $\overset{c}{c}$*ih P*^{o} *balam*, "ô *Maria xbalam. Balam* se llama el echizero.

Varea, Calepino.

In the last entry quoted, we find that *balam* was the name of one of the days of the Kiche-Cakchiquel calendar. It was in fact the twelfth of their week of twenty days, and in the Mexican calendar *ocelotl* stood for the fourteenth of the twenty days. *Queh*, the deer, was also the name of a sign or day, the seventh in the Kiche-Cakchiquel calendar; but was also used to ex-

* "Les Petits Tigres," *Mythes de l'Antiquité Américaine*, § viii; *Popol Vuh*, p. 34, note.

† *Compendio de Nombres en Lengua Cakchiquel. MSS.*

‡ *Las Historias del Origen de los Indios*, p. 16.

press two, thirteen, five or six days, as is stated by Varea in the following entry in his *Calepino*.

"*Queh:* el venado. Ha se estendido la significacion à mulas, caballas "y machas. Sig^{a} un cierto dia; otras veces dos dias; otras veces es signo "de trece, otras veces cinco ò seis dias à la quenta de los Indios: *xa hun "queh væ* $^{c}_{c}$*ih, ô, cay queh, voo quch, vahaki, ò, oxlahuh queh.*

It is not easy to explain the principles which governed the calculation of time among the Kiche-Cakchiquel tribes, only vague and contradictory accounts concerning it having reached us, the analysis of which I trust to undertake in another article. Suffice it to say here that the hero-god whose name is thus compounded of two signs in the calendar, who is born of a virgin, who performs many surprising feats of prowess on the earth, who descends into the world of darkness, and sets free the sun, moon and stars to perform their daily and nightly journeys through the heavens, presents in these and other traits such numerous resemblances to the Divinity of Light, reappearing in so many American myths, the Day-Maker of the northern hunting tribes, that I do not hesitate to identify the narrative of Xbalanque and his deeds as one of the presentations of this widespread, this well-nigh universal myth, guarding my words by the distinct statement, however, that the identity may be solely a psychological, not a historical one.

It will not be without interest to trace the *balam* myth in its later development. We see in the quotation from the *Diccionario de Motul*, that the title was applied to the priests, chief and rulers on whom the defence of the city rested. There were also, in Yucatan, four certain divinities closely connected with the Calendar, called the *Bacabab*. The myths of these correspond in a general way with that of Xbalanque, sufficiently so to recognize that they played a corresponding part, and the *balam* and the *bacab* have been identified in modern Maya superstition. The four *bacabab* were four giants (*chaac*) who sustained the heavens, presided over the years, were the gods of rain and agriculture, who sent the winds on their swift journeys, and hurled the lightning flash from the heavens. The memory of these mighty beings is still preserved by the native Mayas of Yucatan, and even with all their devotion to the Romish Church, they do not neglect the pious rites to these ancient and beneficient national divinities; and what is to my purpose here, is the fact that they still pay them homage under this very name of the *Balams*. In Maya the plural termination is *ob*, and with the masculine prefix *h*, their name becomes *Hbalam ob*.

I have in my possession a Spanish manuscript written in Yucatan about twenty years ago, in which are collected various superstitions still prevalent among the natives. The accounts are from different sources, and as the matter is both new to students of such matters and of importance in tracing the development of the religious notions of the natives, I shall give a translation of those paragraphs which describe the still prevalent belief in the Hbalamob. The authorities given for the account are the

eminent antiquary, Don Crescencio Carrillo, Don Jose Maria Lopez, and the Licenciate Zetina of Tabasco.

"The *Hbalamob* are certain very ancient men who take charge of and "guard the towns. One of them is constantly on the watch on the "north side of the town, another on the south, a third on the east, and "a fourth on the west. During the day they are invisible, although "they are occasionally seen; but those who have this privilege are very "sure to meet soon afterwards with some serious misfortune, as to be "stricken dumb for a while, or to be attacked with a dangerous malady.

"As soon as night arrives the Hbalam becomes more alert and vigilant, "without which the town would soon suffer great misfortune. A violent "rain, a hurricane or a plague would promptly visit it. Although rarely "seen even at night, one may often hear the shrill whistle with which "they call to each other for assistance in repelling the malignant in- "fluences which would assail the town. These the native represents to "himself as personified in individuals, as did the ancient Romans and "Greeks.

"The whistle which is their signal to each other is so loud and shrill that "it can be heard from one end of the town to the other, no matter how "far that may be. United, they oppose with all their might the malig- "nant powers which would attack the town. Such is their gigantic "strength that the day after a conflict of this kind one will find the "arena of the contest strewn with large trees broken down, torn up by "the roots and split into fragments, and the earth is beaten and up- "heaved in a manner that could not proceed from any human agency; "even large stones have been broken into pieces in such battles.

"Although the Hbalam has no wings, he has the power of flying through "the air.

"Not only the natives but the whites of the interior have implicit faith in "these mysterious beings. There is not an Indian who has a corn-field "who omits to propitiate on the proper day the Hbalamob by a suita- "ble offering. This is a very ceremonious act which is presided over by "the *hkin* (native priest), and were it neglected, the corn would wither "for want of rain or for some cause be ruined.

"When an Indian is reproached with the error of believing in the exist- "ence of these Hbalamob, which he has never seen, he contents him- "self with the reply; '*Ah! bix-maheb hah!*' 'Ah! How can it be "otherwise than true!'

"They are, however, seen on various occasions. Thus they say that an In- "dian and his wife once went to their cornfield to gather ears. While "at work the Indian left the field to get some water, and his wife threw "off the gown she wore lest it should be torn, and was naked. Sud- "denly she heard some one call to her in a loud voice: '*Pixe auito "xnoh cizin*': (*Tapa ta culo, gran diablo*); at the same time she received "two smart blows with a cane. She turned and saw a tall man with "a long beard and a gown which reached to the earth at his feet.

"This was the Hbalam. He gave her two more blows and disappeared,
"and she bore the marks of the four cuts the rest of her life.

"At another time, in the province of Tihosuco, an Indian had forgotten to
"offer the Hbalam a gift when the corn was planted. As the ears were
"about ripening he visited his field to look at them. He found in it a
"tall man who was engaged in picking the ears one by one, and placing
"them in a *xuxac*, or large basket, which, according to the custom of
"the country, he carried fastened to his shoulders. The Indian saluted
"him with some mistrust. The other, who was, in fact, the Hbalam,
"answered the salute curtly and added: 'I am here gathering in that
"which I sent.' Shortly afterwards he took from his pouch an immense
"cigar, 'such as the Hbalamob are accustomed to smoke' parenthetic-
"ally added the narrator, and picking up his flint and steel began to
"strike sparks. But the sparks he struck were flashes of lightning, and
"the sound of his blows was terrible thunderclaps which shook the very
"earth, and the Indian fell to the ground unconscious with terror.
"When he came to himself, a hail storm had destroyed his corn. On
"his return he fell sick with a fever which nearly cost him his life.

"It is a general belief among the Indians that the shooting stars are
"nothing else than the stumps of their huge cigars thrown away by the
"Hbalamob."

Returning to the myth of Xbalanque, it is evident that in the Popol Vuh one important part of it is omitted, that is, the portion describing his actions after returning from the underworld, and we can but meagrely supply this omission from other sources. According to the earliest authorities, his egress was made at Coban in Vera Paz, and after he had come forth he stopped up the aperture or cavern, so that no other one could descend.*

The divinities Hun Batz and Hun-choven are represented in the Popol Vuh as skilled in painting, singing, playing the flute, in working gold and jewels, and in cutting stones. Several meanings can be given to each of these names. Hun-Batz is translated by Ximenez *a thread;* its proper form is Baq, in Cakchiquel, from the verb to spin, weave, and I presume refers to Hun-Batz as presiding over the textile arts. Hun-choven is stated by Ximenez to mean *one who is neat* (uno que esta en orden); by Brasseur, *un qui s'embellit.* The verbal form *chove* is rendered by Varea "blanquearse," to whiten, bleach or polish up. This, too, seems to bear a distinct reference to the arts. Their mother is Xbakiyalo, from *x*, female prefix, *bak*, bone or bones, and *yaloh*, to keep together. Ximenez translates it literally *tied bones* (huesos atados), but it should be "She who preserves the bones," and probably has reference to the general care with which the bones of the dead were preserved with religious respect by various members of the Red Race.

* Hieronimo Roman, *De la Repub'ica de las Indias Occidentales*, Lib. II, cap xv. (Salamanca, 1555).

The father of these divinities was Hun-hun-ahpu, himself the son of the original pair, Xpiyacoc and Xmucane.

The Abbé Brasseur has taken pains to make this myth of the two brothers appear to be of Nahuatl origin. On the contrary, there is strong evidence that it is essentially a Maya myth, and originally bore a close relation to others prevailing in Yucatan. This evidence is found in the pages of Father Hieronimo Roman, and I regard the version he gives of so much interest that I will translate it from the third part of his extremely scarce work *Las Republicas del Mundo*, published at Salamanca in 1595.

"Their tradition says that there were a husband and wife who were "divine. The man was called Xchel, and the woman Xtcamna. They "considered these two father and mother, having three sons. The oldest "together with some others grew arrogant, and desired to make creatures "for themselves against the wish of the father and mother; but they "could not, because the work which came from their hands turned out to "be only old earthenware fit for common purposes as for pots and pans, "and other utensils of yet meaner uses. The younger sons who were "called Huncheuen and Hunahan asked permission of their father and "mother to make creatures, and they received it, their parents saying "they might have it because they had demeaned themselves humbly. "They at first made the heavens and the plants, fire, air, water and "earth. Then they made man from the earth. The others who pre-"sumptuously tried to make creatures against the will of the parents "were cast into the infernal regions. All the natives who are engaged "in the arts, such as painters, weavers of feathers, sculptors, workers in "silver and gold, and the like, honor highly these two younger brothers, "and ask their favor and aid in order to obtain skill in their arts and "trades, but they do not believe them to be the highest divinity."*

In this narrative Roman gives the name of Hun ahau (*ahan* is an obvious misprint), instead of Hunbatz; and assigns to them as parents the distinctively Maya divinities Itzamna, the mythical civilizer and discoverer of picture writing, and Xchel, the goddess of medicine, childbirth, etc., although he confuses the sex of the parents. It is an interesting proof of the antiquity of the legend, and of its extension into the pure Maya speaking communities, with whom probably it was a relic of very ancient myths common to the Maya-Kiche stock.

I have reserved for a special subject of discussion the relationship of some of the names of divinities in the Popol Vuh to those of the Aztec mythology. It is the received and favorite theory with many that the civilization of Guatemala was at first a legacy from some Nahuatl speaking race, either Toletcs or Aztecs. The substantial identity of the mythologies of the two peoples has also been assumed. How far the identity extended, I shall now examine.

* *De la Republica de las Indias Occidentales.* Lib. ii, cap xv. This extract is also given by Garcia, *Origen de los Indios*, Lib. v, cap vi, but he has completely distorted the proper names.

Certainly the native writer of the Popol Vuh claims a common origin with the Nahuatl race. Like them he traces his descent from the mythical seven caves, seven ravines or seven sons which are familiar in Aztec myth. He quotes an ancient song which began with the words *Kamucu*, we see, which ran like this:

"Alas, in Tulan were we ruined, there we separated, there they re-
"mained behind, our brothers, our kinsmen. We indeed have seen the
"sun, but they, where are they now, now that the day is breaking?

"Thus did our ancestors chant to the priests, the Yaqui men.

"Verily, the god named Tohil is the god of the Yaqui men, Yolcuat
"Quetzalcoat by name, when we separated in Tulan, in Zuiva. Thence
"indeed came we forth together; there was the common parent of our
"race whence we came. So said they one to another.

"Then they called to remembrance their brothers, there, far off, behind
"them, the Yaqui men, where the day came, in Mexico, as it is now
"called."

The "Yaqui men," *yaqui vinak*, was and still is the common term in Kiche and Cakchiquel for the Aztecs; *yaqui* itself being an adjective in those dialects signifying polished, cultivated, civilized.* There was undoubtedly frequent commercial intercourse between the Aztec and neighboring races, and among the descendants of the original seven brothers were claimed to be such totally diverse races as the Otomis and Tarascos, so that it is not surprising that the early Kiches in a measure accepted an origin from the same prolific source. Tohil and Quetzalcoatl resemble each other in vague outlines, and hence the scribe identified them just as Tacitus identified the Teutonic Thor with the Latin Vulcan. There is no real similarity between the two.

The name Chimalmat also appears in the Quetzalcoatl myth in the form Chimalmatl. According to one account, she was the second wife of the father of men, Iztac-mixcohuatl and the mother of Quetzalcoatl; or she was a virgin, and finding a *chalchihuitl*, a sacred green stone, swallowed it, and becoming pregnant bore Quetzalcoatl; or again she was the wife of Camaxtli, god of hunting and fishing, and had by him five sons, one of whom was Quetzalcoatl.† The name in Nahuatl is from *chamalli*, a shield, and probably *matlalin*, dark green. We find her in the Popol Vuh as the wife of Vukub Cakix, Seven Aras, the ara being the bird of brilliant tropical plumage called in Aztec the Quetzal. Although her name can be explained as a Kiche word, it is most probably a loan from Mexican mythology.

The name *tepeu* which I have derived from a Maya root is found also in

*The Yaqui tribe in Sonora has no connection with this tradition, the identity of names being accidental, and the meaning of the words different. *Yaqui* is also an Aztec word meaning "departed or gone away to some other region," emigrants (ido ó partido para alguna parte, Molina, *Vocabulario Mexicano*, s. v.).

†These various myths are given in Toribio de Motilinia, *Historia de los Indios de Nueva España, Epistola Proëmial*, p. 10, and Geronimo de Mendieta, *Historia Ecclesiastica Indiana*, Lib. ii, cap xxxiii.

PROC. AMER. PHILOS. SOC. XIX. 109. 4c. PRINTED JAN. 17, 1882.

Nahuatl with almost the same significations, as will be apparent from the following quotations from Molina's *Vocabulario Mexicano* (Mexico, 1578).

"**Tepanaui,** el que excede a los otros y les lleva ventaja en algo, ô "el que es vencedor.

"**Tepan nicac,** presidir ô governar (*nicac* is an adverbial ending "signifying presence in time and space, here is, there is).

"**Tepeuani,** conquistador ô vencedor de batalla."

The same may be said of the Kiche and Maya word *ahau*, chief, lord, often applied to divinities; this, too, reappears in Nahuatl in the sense of enjoyment, ease, taking one's pleasure, as a great ruler is supposed to do. The following are also from Molina.

"*Ahauia*, regozijarse, y tomar placer.

"*Ahauiltia*, espaciarse, recrearse ô pasear tiempo.

"*Ahauixca*, alegremente."

But the careful student in comparing these words and their derivatives in Aztec and Maya will find that while in the latter tongue their whole history can be traced from the primary, literal, concrete meaning through the secondary, transferred and metaphorical senses, this is not the case in Aztec, but that in it they appear only with a late secondary signification. This is conclusive evidence that the borrowing was not from Aztec to Maya, but from Maya or its dialects to Aztec, and this at a comparatively late date in linguistic history.

I shall illustrate this by another example. I have previously traced the development of the name Nanauac from a Maya root, branching off, and extending through an interesting series of related conceptions. Words from this same root are also found in Aztec, but all derived from a late form, and in a bad sense. Molina gives:

"*Naualli*, bruxa.

"*Nauallatia*, esconderse para asechar ô hacer mal à otro.

"*Nauallotl*, negromancia ô cosa semejante."

No other significations are given by Molina to words from this root except such as relate to sorcery and witchcraft. Evidently the Aztecs had borrowed it after it had reached this meaning in its development, and it would be in vain to attempt to show its history from Nahuatl sources, whereas this is easy from the Maya dialects. These examples therefore point strongly to the conclusion that the resemblances or occasional identities between Kiche and Aztec myths are superficial ones only, brought about by a limited but long continued intercourse between the two peoples, and that the main and fundamental conceptions of Kiche mythology do not point to any Aztec or Toltec source, but strongly and decidedly to the pure Maya myths and tongue.

As a probable Aztec infiltration; I may mention the myth of the terrestrial paradise called in the Popol Vuh *Puzil*. This word has given trouble to the commentators, and no satisfactory sense has been made out of it viewed as a Kiche expression. I am inclined to believe it a reminiscence

of the Aztec Tlaloc and his happy abode. He was the god of rain, "distributor of the waters" (repartidor de las aguas), and the joyous spot where he passed his time was called *Pahaà*, properly *Pahatlan*, from *pahatl*, rose water, sweet unguent, or other such substance to strengthen and refresh the body.* The waters, the timely rains, refresh and rejuvenate nature, and whence they come, their source and home, was in the imagination of the Aztecs preëminently the land of life, joy and abundance, the terrestrial paradise.

While I am anxious to give full weight to these affinities between the Maya-Kiche and the Aztec mythology, I must formally protest against the strained efforts at identifying the divinities and myths of the one race with that of the other, as has been done in many parts by Brasseur and in an even more pronounced manner by Mr. H. H. Bancroft.† I wish to state clearly my adherence to the opinion that the theogonies of the Maya and Nahuatl stocks were distinct in origin, different in character, and only similar by reason of that general similarity which of necessity arose from the two nations being subject to like surroundings, and in nearly the same stage of progress. The two nations had for generations frequent commercial intercourse; certain features of the religion of the one may have been borrowed from the other, as were certain words of the language; but to explain the attributes of a Maya-Kiche divinity by those of an assumed Mexican analogue is a hazardous and uncritical proceeding; and to take it for granted that historically the one mythology is a descendant of the other is a gratuitous assumption wholly without support by the facts so far as we know them, and at present contrary to probability.

It will be noticed in some of the above names how prominent the perception of color shows itself. This is very strongly marked in these dialects. There is, however, no evidence that they distinguished colors to a refined extent. On the contrary, Coto distinctly confines the names of colors to five: "Los nombres de colores no tienen mas de cinco" (s. v. *Color*).

As I have above said, travelers maintain that the natives do not distinguish green from blue; in Kiche, *rax*, in Maya *yaax*, stands for both these shades. The names of these five main colors are constantly recurring as signs and metaphors. They are:

	Kiche.	Cakchiquel.	Maya.
White,	zak,	zak,	zac.
Black,	gek,	g'ek,	ek.
Red,	cak,	cak,	chac.
Green,	rax,	rax,	yaax.
Yellow,	gan,	g'an,	kan.

*"El lugar de Tlaloc, que era la tierra de *Phajaá*, descanso y bien aventuranza." Joseph Joaquin Granados y Galvez, *Tardes Americanas*, p. 87. (Mexico, 1778.) This author, though well acquainted with Otomi, was not proficient in Aztec. There is no *ph* nor *f* sound in Aztec. The word *pahatl* is given by Molina with the significations stated in the text.

†*Native Races of the Pacific States*, Vol. iii, chap. xi.

The poverty of this list was eked out by certain terminations which modified the force of the root, as in Maya *pozen*, which indicated that the tint was light or shaded toward white (Pio Perez); and so Coto gives for the blue color of the sky *rax gorogoh* or *rax hanahoh* (s. v. *Azul*), and for brown *rax magamoh*, etc. Hence I judge that the deficiency of the color sense above referred to was apparent rather than real.

The *Popol Vuh* informs us that there is a spot where four roads meet, each of a different color, the one red, the second black, the third white, and the last yellow or green (pp. 82, 143). This is a reminiscence of the use of the colors as symbols of the cardinal points of the horizon. The same four colors were, according to Landa, used by the Mayas on their "Katun wheel," by which they counted their calendar, and each was sacred to one of the four dominical letters of their calendar.

The custom of identifying a color with one of the cardinal points was common in Yucatan and Mexico, as well as elsewhere in the New and Old World. It has been studied in both by M. de Charencey, who believes that in Mexico and Central America the original systems were as follows:*

Quaternary System.		Quinary System.	
East,	Yellow.	South,	Blue.
North,	Black.	East,	Red.
West,	White.	North,	Yellow,
South,	Red.	West,	White.
		Center.	Black.

This symbolism in the form of its existence in Guatemala has not yet been made out. I observe that in Cakchiquel the term for red, *cak*, also meant North (*cak ig*, north-wind, Coto. s. v. *Ayre*).

The word *rax*, green or blue, as I have above mentioned, was used also in the sense of strong, violent, great, magnificent. It, in fact, almost lost its meaning as connoting a particular hue, and was applied, for instance, to any precious stone of no matter what color. Thus, says Coto, "á todas las piedras de estima y relucientes llama el indio *raxavon*, de qualquier "color que sean; piedra de anillo, *raxavon ru vach nar*$^{e}_{c}$*a*, que es el "anillo."

Both green and yellow were esteemed fortunate colors by the Cakchiquels, the former as that of the flourishing plant, the latter as that of the ripe and golden ears of maize. Hence, says Coto, they were also used to mean prosperity: "para significar prosperidad usan deste nombre *ganal*, "y *raxal* que es verde; v. g. *goh ganal, raxal, ru chahim Pedro.*" The god *Kanil*, is still honored by the Kiches, as the protector of the harvest†.

Nevertheless, yellow was the color used in mourning, and the bereaved one painted himself with a yellow earth, as we learn from Ximenez: "El luto que usaban era untarse de tierra amarilla, de adonde tome el

* *Des Couleurs considérées comme Symboles des Points de l'Horizon chez les Peuples du Nouveau Monde.* Actes de la Société Philologiques, Tom. vi.

†Scherzer, *ubi supra*, p. 12.

"nombre *mal-cane* el viudo, que quiere decir el untado de amarillo" (*Escolios*, p. 214).

The color white, *zak*, had, however, by far the widest metaphorical uses. As the hue of light, it was associated, with day, dawn, brightness, etc.; to dawn, *ti zaker;* the daybreak, *maha ti zaker;* a clear sky, *rax cah;* light, *zak;* clearness, translucency, *zak il*. As applied to abstract ideas its employment was very frequent as "clearly, manifestly," *chi zakil*. In the Popol Vuh are such expressions as *zakil golem, zakil tzih*, literally "the whiteness life, the whiteness words," which mean "the glory of life, the glory of speech." The mythical mother and father of the race are called *zakil al, zakil qahol*, she who gives birth to whiteness, he who begets whiteness, where the whiteness is to be understood as mental clearness, knowledge, enlightenment. Varea gives *zak iricah*, to make clear, to explain, *zak*, a clearing in the woods, and other derivatives.

In closing this exegetical study, I would point out one fact developed by it, to which I attach considerable weight, and that is that the names analyzed indicate unmistakably a source immeasurably remote from Christian thought, and thus prove the aboriginal origin of this important myth. Can any one maintain that it was an echo of missionary teaching, when the names it applies to the highest god are such as "the Great Hog," "the Fox, mighty in Magic," "the Syphilitic One," and the like? Such appellations, at first sight so degrading to the notion of God, can only be understood by taking into account modes of thought, and associations of ideas wholly divergent from those to which these tribes were introduced by the ministers of the Christian religion.

Stated Meeting, December 2d, 1881.

Present, 6 members.

President, Mr. FRALEY, in the Chair.

Letters accepting membership were received from John Evans, dated Nov. 5, 1881, Nash Mills, Hamel-Hempstead; Henry H. Gorringe, Nov. 30, Portland, Oregon; William Gladstone, Prime Minister of England, Nov. 15, 10 Downing St., Whitehall (through G. L. Gower); and B. Stallo, Nov. 18, Cincinnati.

A letter of acknowledgment was received from the Royal Institution, London. (Proc. 107, 108; Trans. XV, 3.)

A letter of envoy was received from the North China

Branch of the Royal Asiatic Society, dated Shanghai, Oct. 25, 1881.

A letter requesting the completion of sets of Proceedings and Transactions of this Society, was received from Cornell University, Ithaca, N. Y., dated Nov. 22, 1881. The matter was referred to the Secretaries, with power to act.

A circular letter was received from the Secretary of the Prince Edward Island Historical Society, dated Nov. 17, 1881, Charlottetown.

Donations for the Library were received from the Mining Bureau, Melbourne; Royal Academy, Berlin; Zoologischer Anzeiger, Leipzig; Society of Northern Antiquaries, Copenhagen; Oesterreichischer Ingenieur- und Architekten Verein, Wien; Annales des Mines, and Revue Politique, Paris; Bordeaux Society of Commercial Geography; Royal Astronomical Society, and Nature, London; Mr. Robert C. Winthrop, Boston; Essex Institute, Salem; American Journal of Sciences, New Haven; New York Historical Society; American Chemical Society, N. Y.; Academy of Natural Sciences, The American, and Mr. Henry Phillips, Jr., Philadelphia; U. S. National Museum, and the Bureau of Education, Washington; The Virginias, Staunton, Va.; and State Historical Society of Wisconsin.

A photograph and a phototype of the late member Wm. Rawle, Esq., were presented to the Society by Mr. Brooke Rawle.

A paper by Prof. J. J. Stevenson, entitled "Notes on the Laramie Group in the vicinity of Raton, New Mexico," was read by title.*

Mr. Lewis read a paper upon a new substance resembling Dopplerite found in a peat bog near Scranton.*

A communication was read from Mr. Lesley stating that he had gone away for two or three months, and enclosing a report upon the manner in which he intended to, and had already examined and partly copied the old minutes of the Society. Postponed to Dec. 16th.

* These papers will be printed in Vol. xx, No. 111.

The Treasurer's report was read and referred to the Finance Committee.

Pending nominations Nos. 935 and 946 to 950 inclusive were read.

Proceedings of the Officers and Council submitted at the last meeting, were made special order for next meeting; and to be placed on the notice cards.

On motion of Mr. Price, it was moved that $20,000 additional insurance be placed on the Library. Carried.

And the meeting was adjourned.

Stated Meeting, December 16, 1881.

Present, 16 members.

President, Mr. FRALEY, in the chair.

A letter accepting membership was received from Mr. A. Renard, Conservateur du Musée Royal d'Histoire Naturelle de Belgique, Bruxelle, dated Vienna, Nov. 19, 1881.

Letters of acknowledgment were received from the Royal Society of Edinburgh, Nov. 15, 1881 (Proc. 107, 108; Trans. XV, 3); and the Society of Antiquaries, London, Dec. 1, 1881 (107, 108; XV, 3).

Letters of envoy were received from the Physical Central Observatory, St. Petersburg, Oct., 1881; Musée Guimet, Lyon, Nov. 17, 1881; Dr. G. M. Gibson, 1 Randolph Cliff, Edinburgh, Nov., 1881; Mr. Edward Coles, 205 S. 6th Street, Philadelphia, Nov. 23, 1881, and the Department of the Interior, Washington, Dec. 12, 1881.

A postal card requesting volumes of Transactions published since Volume XII, was received from the University of Toronto, dated Dec. 8, 1881. Referred to the Secretaries.

A letter from Mr. B. V. Marsh was read, dated Dec. 9, 1881, tendering his resignation as Trustee of the Building Fund. The

resignation was accepted, and on motion the thanks of the Society were tendered to Mr. Marsh for his faithful services.

Donations for the Library were received from the Royal Society of Victoria, Melbourne; the Royal Prussian Academy, Berlin; Zoologischer Anzeiger, Leipsig; Senckenberg Natural Science Society, Frankfurt a-M.; R. Accademia dei Lincei, Rome; Geographical Society, Revue Politique and M. L. Gruner, Paris; Society of Commercial Geography, Bordeaux; Journal of Forestry, Nature, Nautical Almanac Office, and Mr. C. Wm. Siemens, London; Geo. A. Gibson, M.D., Edinburgh; Nova Scotia Institute of Natural Science, Halifax; Museum of Comparative Zoology, Cambridge; Yale College, New Haven; New York Academy of Science, and the editors of "Science," "Health and Food," and The Chemists' and Druggists' Bulletin, New York; American Journal of Pharmacy, Medical News, The American, Mr. Dalton Dorr, Mr. Henry Phillips, Jr., and Mr. Edward Coles, Philadelphia; American Journal of Mathematics, Baltimore; U. S. National Museum, Light House Board and Department of the Interior, Washington, and the Virginias, Staunton, Va.

The death of Mr. W. Milnor Roberts was announced by the President.

On motion of Mr. Henry Phillips, Jr., the President was requested to appoint a proper person to prepare an obituary notice of Mr. Roberts.

Mr. Eli K. Price read a description of the Rockery on the grounds of the University at West Philadelphia.

Prof. Cope presented two papers on the geological exploration of the Big Horn Region, with especial reference to the Eocene period.

Rev. Dr. Boardman announced that he would read a communication on the history of alphabets.

The report of the Committee of Finance was postponed to the next meeting.

Under deferred business the Society proceeded to the consideration of the resolution of the Officers and Council to celebrate the birthday of Franklin.

Mr. Phillips spoke in favor of the resolution.

The resolution was agreed to, and a Committee consisting of Mr. Henry Phillips, Jr., Mr. J. S. Price, and Mr. Wm. A. Ingham was appointed to attend to the matter.

A communication from the Librarian in reference to printing the early minutes of the Society was laid before the Society by the President.

Mr. Price moved to postpone consideration of the matter for the present.

Mr. Phillips moved that the suggestion in the Librarian's report in regard to the MSS. be referred to a committee of five to report to the Society.

Mr. Henry Phillips, Jr., Dr. Horn, Mr. H. C. Lewis, Dr. Brinton, and Mr. Philip Law were appointed as Committee.

The President announced vacancies in the Trusteeship of the Building Fund.

It was moved by Mr. Price that the Society proceed to fill the vacancy in the Trustees of the Building Fund.

On motion, Mr. Richard Wood, Mr. J. Sergeant Price and Mr. Wm. V. McKean were elected.

And the meeting was adjourned.

PROC. AMER. PHILOS. SOC. XIX. 109. 4D. PRINTED JAN. 17. 1882.

GEOLOGICAL MODEL
OF PART OF
BLAIR, BEDFORD AND
HUNTINGDON COUNTIES
PENNSYLVANIA.
BY E.B. HARDEN.
From Surveys of H. D. Rogers.
Second Geological Survey
of Pennsylvania.
SCALE OF MILES.
SCALE OF COLORS.

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CHAPTER XII.

OF THE MAGELLANIC FUND.

SECTION 1. John Hyacinth de Magellan, in London, having in the year 1786 offered to the Society, as a donation, the sum of two hundred guineas, to be by them invested in a secure and permanent fund, to the end that the interest arising therefrom should be annually disposed of in premiums, to be adjudged by them, to the author of the best discovery, or most useful invention, relating to Navigation, Astronomy, or Natural Philosophy (mere natural history only excepted); and the Society having accepted of the above donation, they hereby publish the conditions, prescribed by the donor and agreed to by the Society, upon which the said annual premiums will be awarded.

CONDITIONS OF THE MAGELLANIC PREMIUM.

1. The candidate shall send his dicovery, invention or improvement, addressed to the President or one of the Vice-Presidents of the Society, free of postage or other charges; and shall distinguish his performance by some motto, device, or other signature, at his pleasure. Together with his discovery, invention, or improvement, he shall also send a sealed letter containing the same motto, device, or signature, and subscribed with the real name and place of residence of the author.

2. Persons of any nation, sect or denomination whatever shall be admitted as candidates for this premium.

3. No discovery, invention or improvement shall be entitled to this premium which hath been already published, or for which the author hath been publicly rewarded elsewhere.

4. The candidate shall communicate his discovery, invention or improvement, either in the English, French, German, or Latin language.

5. All such communications shall be publicly read or exhibited to the Society at some stated meeting, not less than one month previous to the day of adjudication, and shall at all times be open to the inspection of such members as shall desire it. But no member shall carry home with him the communication, description, or model, except the officer to whom it shall be entrusted; nor shall such officer part with the same out of his custody, without a special order of the Society for that purpose.

6. The Society, having previously referred the several communications from candidates for the premium, then depending, to the consideration of the twelve counsellors and other officers of the Society, and having received their report thereon, shall, at one of their stated meetings in the month of December, annually, after the expiration of this current year (of the time and place, together with the particular occasion of which meeting due notice shall be previously given, by public advertisement) proceed to final adjudication of the said premium; and, after due consideration had, a vote shall first be taken on this question, viz.: Whether any of the communications then under inspection be worthy of the proposed premium? If this question be determined in the negative, the whole business shall be deferred till another year; but if in the affirmative, the Society shall proceed

to determine by ballot, given by the members at large, the discovery, invention or improvement most useful and worthy; and that discovery, invention, or improvement which shall be found to have a majority of concurring votes in its favor shall be successful; and then, and not till then, the sealed letter accompanying the crowned performance shall be opened, and the name of the author announced as the person entitled to the said premium.

7. No member of the Society who is a candidate for the premium then depending, or who hath not previously declared to the Society, that he has considered and weighed, according to the best of his judgment, the comparative merits of the several claims then under consideration, shall sit in judgment, or give his vote in awarding the said premium.

8. A full account of the crowned subject shall be published by the Society, as soon as may be after the adjudication, either in a separate publication, or in the next succeeding volume of their Transactions, or in both.

9. The unsuccessful performances shall remain under consideration, and their authors be considered as candidates for the premium for five years next succeeding the time of their presentment; except such performances as their authors may, in the meantime, think fit to withdraw. And the Society shall annually publish an abstract of the titles, object, or subject matter of the communications, so under consideration; such only excepted as the Society shall think not worthy of public notice.

10. The letters containing the names of authors whose performances shall be rejected, or which shall be found unsuccessful after a trial of five years, shall be burnt before the Society, without breaking the seals.

11. In case there should be a failure, in any year, of any communication worthy of the proposed premium, there will then be two premiums to be awarded the next year. But no accumulation of premiums shall entitle the author to more than one premium for any one discovery, invention or improvement.

12. The premium shall consist of an oval plate of solid standard gold of the value of ten guineas. On one side thereof shall be neatly engraved a short Latin motto suited to the occasion, together with the words: "The Premium of John Hyacinth de Magellan, of London, established in the year 1786;" and on the other side of the plate shall be engraved these words: "Awarded by the A. P. S. for the discovery of ——— A. D———." And the seal of the Society shall be annexed to the medal by a ribbon passing through a small hole at the lower edge thereof.

SECTION 2. The Magellanic fund of two hundred guineas shall be considered as ten hundred and fifty dollars, and shall be invested separately from other funds belonging to or under the care of the Society, and a separate and distinct account of it shall be kept by the treasurer.

The said fund shall be credited with the sum of one hundred dollars, to represent the two premiums for which the Society is now liable.

The treasurer shall credit the said fund with the interest received on the investment thereof, and, if any surplus of said interest shall remain after providing for the premiums which may then be demandable, said surplus shall be used by the Society for making publication of the terms of the said premium, and for the addition, to the said premium, of such amount as the Society may from time to time think suitable, or for the institution of other premiums.

The treasurer shall, at the first stated meeting of the Society in the month of December annually, make a report of the state of said fund and of the investment thereof.